On the Design of a Mobile Executive Functioning Coaching Solution for Students with and without Disabilities in Post-Secondary STEM Education

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Abstract

Existing literature indicated that supporting the executive function skills (EFs) and learning strategies of students with disabilities (SWDs) during the learning process is important for improving the persistence and success of those students in post-secondary Science, Technology, Engineering, and Mathematics (STEM) education. This study investigated the integration of academic coaching on a mobile technology platform to support the EFs and learning strategies necessary for the success of SWDs in post-secondary STEM. Universal Design for Learning (UDL) (CAST, 2011) was utilized as the conceptual framework to guide this study. A parallel mixed methods study was used to collect data to identify students' perceptions on features of this mobile EF coaching to support individual EFs, personal participation outcomes for this mobile EF coaching support, and the differences between this mobile EF coaching support and other types of support services for those students in post-secondary STEM education. A total of seven participants completed the mobile coaching study. The pre/post-test results and the analysis of qualitative content showed improved EFs and learning strategies/skills for those students. Two levels of coding were used to analyze the qualitative data. The implications and limitations of the study were discussed, and recommendations were made for future research and practice.

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Chapter 1

Introduction

Preparing the science, technology, engineering, and mathematics (STEM) workforce with entrepreneurship, capabilities for creativity, problem solving skills, the willingness to collaborate, and reflexivity is crucial to maintaining an innovative and competitive global civil society (Zhao, 2012). Within the United States, there is an increasing demand for a STEM workforce to strengthen the economy and maintain a leading global role in scientific and technological innovation (National Science Board [NSB], 2010). Approximately one million additional jobs in STEM-related fields will be available by 2020, according to the U.S. Bureau of Labor Statistics (U.S. Department of Labor, 2014). Among the national labor force, 20.5% includes people with disabilities, while 68.4% includes people without disabilities, based on the U.S. Department of Labor's (DOL) Office of Disability Employment Policy (ODEP). However, only 5% of individuals with disabilities are in the STEM workforce (Leddy, 2010). Researchers have identified the importance of including individuals with disabilities in STEM education and careers, which may help them develop advanced knowledge and skills in STEM, prepare them for work-related opportunities leading to a higher quality of life, and increase workforce diversity in STEM fields (Basham & Marino, 2010; NSF, 2015).

When addressing the shortage of qualified STEM workforce, it is necessary to increase access to STEM courses, support active learning, and include historically under-represented groups in advanced education and STEM professions (White House, 2016). Underrepresented groups within science and engineering include individuals with disabilities, women, and racial/ethnic groups (NSF, 2015). As early as 1980, the Science and Engineering Equal Opportunities ACT (1980) required the advancement of technological innovation and inclusion of under-represented groups in STEM fields. Regardless of gender, race, and disability status, there was a call for providing individuals with opportunities to fully participate in the STEM workforce (Lee, 2010). In more recent years, even greater emphasis has been placed on supporting underrepresented groups in STEM fields (Leddy, 2010). For example, the Committee on Equal Opportunities in Science and Engineering promotes broadening the participation of underrepresented groups in STEM fields (CEOSE, 2009).

The Problem

Post-secondary STEM education plays a critical role in equipping the STEM workforce with required skills. However, the number of undergraduates who attain STEM degrees and pursue careers in STEM after graduation is diminishing (Mattern, Radunzel, and Westrick, 2015). The shrinking supply of potential STEM workers can be explained by the low percentage of first-year post-secondary students who declare a STEM major and the high dropout rates among students who choose STEM majors (National Science Board, 2010; U.S. Department of Education, 2012).

With post-secondary education being more accessible to individuals, the existing concerns for post-secondary education are high dropout rates and completion instead of enrollment (Sawhill, 2013). For instance, Mattern and colleagues (2015) reported that only 37% of first-year STEM majors achieve degree attainment in six years. Among those graduates with a STEM degree, only 56% start employment in STEM fields, and many choose non-STEM careers instead (Carnevale, Smith, & Melton, 2011; Lowell, Salzman, Bernstein, & Henderson, 2009). For individuals with disabilities in STEM fields, post-secondary enrollment data has indicated only one in four students choose a STEM major (NSF, 2017). Lee (2011) identified that students with disabilities (SWDs) are more likely to choose STEM majors at two-year colleges compared to students without disabilities. However, the dropout rates for SWDs are even higher than their peers without disabilities in post-secondary STEM education (Lee, 2011), with corresponding lower graduation rates among post-secondary STEM majors (Chen, 2012).

Many factors may correlate with the success and persistence of SWDs in post-secondary STEM, including students' characteristics, STEM courses and performance, precollege experiences, college experiences, and institutional structure (Chen, 2013; Lee, 2011). Indeed, results from longitudinal studies showed how the representation of SWDs gradually decreases through the path of pursuing STEM education due to complex factors (Moon, Todd, Morton, & Ivey, 2012). In a survey of over 2,100 undergraduates, O'neal, Wright, Cook, Perorazio, & Purkiss (2007) identified course performance, lab climate, and learning about careers as factors that impact a student's decision to stay in a STEM major. In addition, many scholars found that bias and discrimination exist toward traditionally underrepresented groups regarding their gender, disability status, race, and social economic status in STEM fields (Espinosa, 2011; Street et al., 2012; Robnett, 2015). When SWDs enter post-secondary STEM majors, they more frequently struggle with performance and persistence in STEM gateway courses, which have high requirements on executive function skills (EFs) (Bellman, Burgstahler, and Hinke, 2015). STEM gateway courses are the initial post-secondary courses (e.g., mathematics, chemistry, biology, physics) in STEM areas taken by a freshman or sophomore who wants to major in a STEM field (O'neal et al., 2007).

Executive Functioning Is Critical for Success

Bellman and colleagues (2015) identified that executive function (EF) deficiency is one of the largest barriers to success and persistence for SWDs in post-secondary STEM. Researchers identified that EF deficits usually impact academic, social, occupational, and psychological functioning (DuPaul et al., 2009; Weyandt et al., 2013). EFs describe the capabilities to manage goal-oriented and purposeful tasks in daily life (Suchy, 2009). Researchers found that EFs (i.e., strategy generation and planning) continuously develop between the ages of 17 to 22 into early adulthood (Romine & Reynolds, 2005). EFs are especially in demand during the transition to independence and autonomy when students start their post-secondary education (Ahmed & Miller, 2011). During that transition, the responsibility of acquiring information, organizing and planning learning, and requesting accommodations and services shifts from special educators and parents to SWDs themselves (Garrison-Wade, 2012). The challenges for those students in transitioning to and pursuing college studies in post-secondary STEM include regularly indicating the struggle to manage time, to make plans, to complete assignments, to organize tasks, and to maintain focus or shift focus from one task to another (Parker & Boutelle, 2009). Specifically, regarding challenges in the learning process, students must understand how to maximize their learning and how to apply learning strategies across environments; they must also have the ability to recall and organize content (Morningstar, Zagona, Uyanik, Xie, & Mahal, 2017). Suggested essential cognitive and behavioral approaches to the learning process may include how to seek information, take notes, plan and organize learning tasks, and use available learning resources (Rachal, Daigle, & Rachal, 2007). Individuals with a range of disabilities, including attention-deficit/hyperactivity disorder (ADHD), learning disabilities (LD), autism spectrum disorder (ASD), depression, or various forms of a brain injury (American Psychiatric Association, 2017), may encounter EF challenges.

The Context

When developing transitional interventions/strategies to support the success and persistence of SWDs in post-secondary STEM education, it is necessary to take complex factors into consideration and to frame these complex issues using an interdisciplinary lens, which broadens the dimensions of understanding and investigating complex issues. It is also necessary to listen to student voices and feedback to understand their learning experiences and to identify their learning needs among complex contextual variables. Deeply understanding an existing issue and identifying students' learning needs is important for intervention and solution development.

In the existing literature, many studies identified research-based practices to support the success and persistence of SWDs in post-secondary STEM education. Some identified practices include: (a) academic mentoring/coaching (e.g., peer-led team learning) (Street et al., 2012), (b) technology tools (Koch, 2016; Street et al., 2012; Hwang & Taylor, 2016), (c) academic counseling (professional perspectives) (Koch, 2016), (d) role models (Summers, 2009), and (e) work-based learning experiences (Bellman, Burgstahler, & Ladner, 2014). It is meaningful to incorporate available research-based evidence and innovative technology tools to satisfy learning needs that support SWDs in post-secondary STEM education. This study will focus on the incorporation of EF coaching with innovative technology tools to support active learning and to improve learning outcomes.

Many studies have begun to explore the incorporation of research-based practices with innovative technology tools, such as mobile devices and related applications, to support cognition development, emotion regulation, communication, and collaboration with students with disabilities (Rodríguez, Strnadová, & Cumming, 2014). With certain features of mobile devices, such as movability, low cost, and wide circulation (Sharples, 2013), the limitations of face-to-face coaching, which include producing immediate feedback and benefits, can be potentially solved (Parker & Boutelle, 2009). Basham, Stahl, Ortiz, Rice, and Smith (2015) argued that individuals with disabilities can demonstrate their strengths when they have access to supportive learning environments; otherwise, those strengths go unnoticed. For instance, Sowers, Powers, & Shpigelman (2012) identified electronic mentoring (e-mentoring) as an effective practice for supporting the retention, persistence, and graduation of underrepresented post-secondary SWDs in STEM majors. The researchers used a user-centered approach to identify the efficacy of standard calendar software to support the cognitive functions and emotional regulation of individuals with brain injuries (de Joode, Proot, Slegers, Heugten, Verhey, & Boxtel, 2012). Generic electronic technologies like personal data assistants (PDA) can provide a platform for enhancing memory and organization skills and may be beneficial to individuals with cognitive disabilities (Gillett & Depompei, 2008). Mobile technologies show potential in supporting active learning, as they impact motivation, engagement, communication, and collaboration (Duncan-Howell & Lee, 2007). Mobile applications, like WhatsApp, have become a shared platform that improve accessibility, encourage collaboration, and strengthen motivation to actively participate in academic learning (Bere, 2013; Chipunza, 2013). In many studies, the terms “mentoring” or “academic coaching” are used interchangeably (i.e., Koch, 2016; Single, Muller, Cunningham, Single, & Carlsen, 2005).

Since the advent of the iPhone in 2007, mobile technology has received great attention in research and practice to support active learning in formal and informal K-16 educational environments (El-Hussein & Cronje, 2010; Park, 2011; Xie, Basham, Marino, & Rice, 2018). Regarding supporting executive functioning, Parker & Boutelle (2009) conducted one study on EF coaching to support skills, strategies, and beliefs development in order to address the EF challenges of SWDs in post-secondary STEM education. In one study on student perceptions of services in college, SWDs revealed that mentoring (i.e., advocacy, emotional support, learning strategies) from the disability services office on campus was the most helpful in improving their post-secondary support (Garrison-Wade, 2012). However, few empirical studies that investigate the design of academic coaching via mobile devices to support EFs development exist. This study investigated the integration of academic coaching on a mobile technology platform to support the learning strategies and skills for the participation and persistence of SWDs in post-secondary STEM.

Definitions of Terms in This Study

Academic coaching is defined as a "one-to-one interaction with a student focusing on strengths, goals, study skills, engagement, academic planning and performance" (Robinson & Gahagan, 2010, p. 27).

EF coaching refers to "a specialty within the burgeoning field of personal coaching, and provides support for the development of skills, strategies, and beliefs needed to manage executive function challenges" (Parker & Boutelle, 2009, p. 205).

Mentoring is defined as "a situation in which a more-experienced member of an organization maintains a relationship with a less-experienced, often new member to the organization and provides information, support, and guidance so as to enhance the less-experienced member's chances of success in the organization and beyond" (Campbell & Campbell, 2000, p. 727). Mentoring is often characterized as an informal process, requires a mutually agreed upon one-to-one relationship, develops a learning alliance, and is reciprocal in nature. In many studies, "mentoring" or "academic coaching" are used interchangeably (i.e., Koch, 2016; Single, Muller, Cunningham, Single, & Carlsen, 2005).

STEM gateway course refers to the introductory course (e.g., mathematics, chemistry, biology, physics) in STEM areas taken by a freshman or sophomore who is preparing for a STEM related major (O'neal et al., 2007).

Persistence in STEM majors refers to a continuous learning process that influences an individual's educational goal aspirations (NRC, 2012; Gregg et al., 2016). Specifically, persistence can be understood as enrollment in the next sequential STEM gateway course in the following semester or staying in the STEM major after the declaration of the major during the admissions process (Street et al., 2012).

Support in inclusive settings refers to helping students fully participate and progress in the general curriculum with broad conceptual and highly specific meaning (Morningstar et al., 2017).

Mobile technology to support academic learning refers to "mobile learning that takes place when the learner is not at a fixed location or learning that happens when the learner takes advantage of learning opportunities provided by mobile devices that are often connected to the Internet" (O'Malley et al., 2005, p. 7).

Academic learning is defined as any time someone can use a mobile device to support information associated with the content or activities related to class.

Significance of the Study

In this study, the researcher intended to develop transitional interventions/strategies to support the success and persistence of SWDs in post-secondary STEM education through examining EF coaching and its design on a mobile platform. Supporting the EFs and learning strategies of SWDs during their learning process is important for improving the persistence and success of those students in post-secondary STEM education. For instance, providing EF coaching to support EF of SWDs is effective in developing the skills, strategies, and beliefs that address their EFs challenges (Parker & Boutelle, 2009). Learning strategies indicate the approaches and skills used by students to advance their learning (Rachal et al., 2007). Rachal and colleagues (2007) indicated that students should receive explicit instruction on how to use learning strategies throughout their academic curriculum during post-secondary education. Morningstar and colleagues (2017) conducted a study to seek out insights and perspectives from experts nationwide on the successful college and career experience for students with severe disabilities. They identified the necessity of preparing students with the knowledge, skills, and experiences associated with engagement in core academics and essential non-academic competencies, including growth mindsets, problem-solving skills, and interpersonal engagement (Morningstar et al., 2017). Engagement in academic settings may manifest as persistence in self-regulating learning, organizing learning, and learning tasks (Rachal et al., 2007).

In addition, supporting the success and persistence of SWDs in post-secondary STEM education and careers will benefit STEM diversity workforce preparation. As the literature mentioned, traditionally underrepresented and underserved groups within science and engineering include individuals with disabilities, women, and racial/ethnic groups (NSF, 2015). Broadening the participation of minorities in STEM education and professions contributes to a diverse workforce in STEM fields (CEOSE, 2009).

Conceptual Framework

The desired and measured change in this study is to improve the EFs of individuals with diverse needs, especially SWDs, for their success and persistence in post-secondary STEM education. Success and persistence are defined as having a positive post-secondary outcome that will stimulate STEM course completion and post-secondary degree attainment (Garrison-Wade, 2012). Specifically, with EFs support and guided learning strategies via mobile applications, SWDs develop EFs and become expert learners in their learning process, being resourceful, strategic, goal-directed, and motivated in their learning (CAST, 2011). A theory of change

(TOC) (Anderson, 2005), the use of a tool for solution development to solve problems in a complex context, was used to understand how to improve the EFs and learning strategies of SWDs in this study. TOC explains assumptions about the process of change occurrence, specifies the methods to bring about the desired sustainable change, and documents the occurrence (Anderson, 2005). Understanding complex learning variables and identifying learners' personalized needs is especially important for improving or designing an innovative educational intervention to support the success and persistence of SWDs in post-secondary STEM education.

Universal Design for Learning (UDL) (CAST, 2011) was utilized as the conceptual framework to guide this study. The research plan includes three main objectives: (1) understand and identify the relationship between EFs and academic outcomes of SWDs in post-secondary STEM gateway courses (i.e., mathematics, physics, chemistry), (2) identify the gap between practices supporting EFs and the integration of innovative technology tools (mobile phones and the application) to support EFs for SWDs in post-secondary STEM, and (3) validate the design of the integration of research-based practices with mobile devices and applications to support EFs for students in post-secondary STEM. Please see Figure 1 to understand the TOC model used in this study.

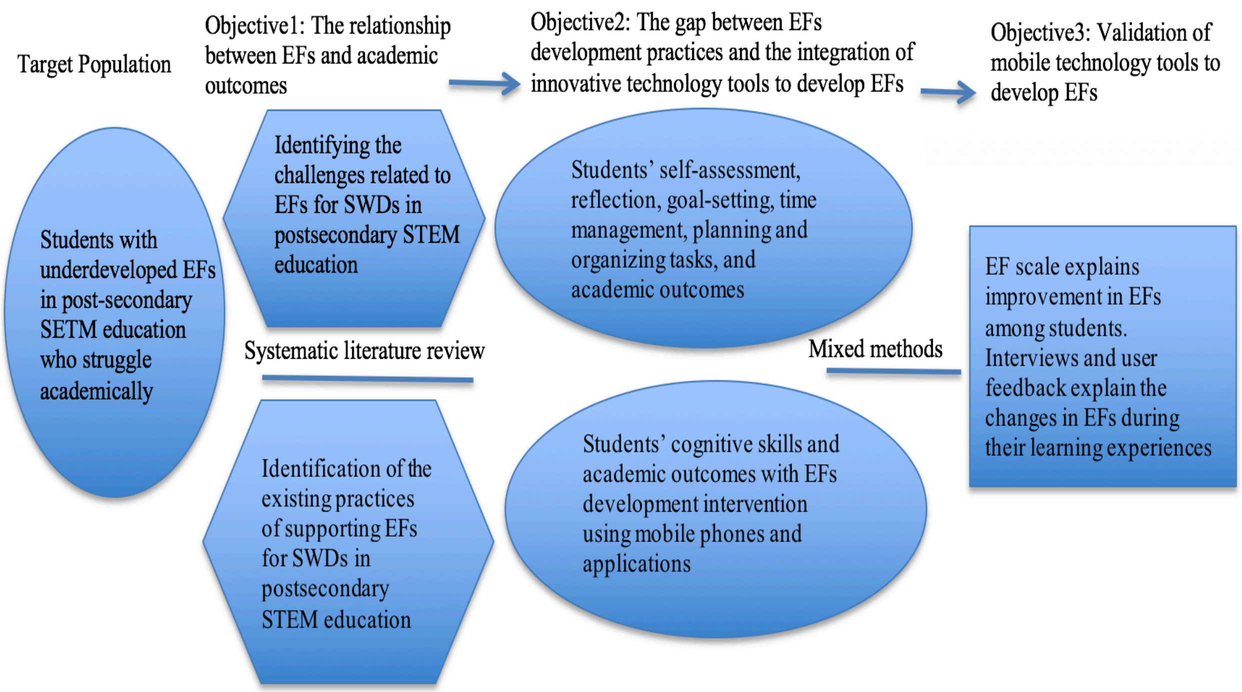

Figure 1 The Theory of Change (TOC) Model

The framework to guide this study is UDL (CAST, 2011). According to the Higher Education Opportunity Act of 2008 (HEOA), UDL is a scientifically validated framework that emphasizes flexibility in information presentation, action and expression of knowledge and skills, and engagement in active learning. At the same time, UDL limits barriers in learning environments, with appropriate accommodations and challenges to support the success of every student (HEOA, 2008). The use of UDL in developing educational resources and designing modern learning environments optimizes teaching and maximizes learning for all people based on research-based evidence of how learning happens (CAST, 2011). In this study, the researcher intends to use the affordances of mobile devices and applications to support learning in complex learning contexts (Sharples, 2013) and to reduce learning barriers for SWDs during the learning process. The UDL framework potentially provides one means to consider the variability needs that exist both across learners and the environment (Basham, Smith, & Satter, 2016; Meyer, Rose, & Gordon, 2014). It is necessary to design and improve educational resources on mobile platforms while considering the UDL instructional design framework.

During the learning process, the use of mobile devices and their applications can be in line with the UDL framework (Reid, Strnadova, & Cumming, 2013). One major purpose of UDL is to reduce learning barriers and to guide students with and without disabilities to become expert learners who are resourceful, strategic, goal-directed, knowledgeable, purposeful, and motivated to learn (CAST, 2011). With the guidance of the UDL framework in this study, the researcher's research efforts will focus on how to expand EF capacity through scaffolding lower and higher level EFs and strategies to support those skills via mobile devices and an application. Please see Figure 2 for information about UDL.

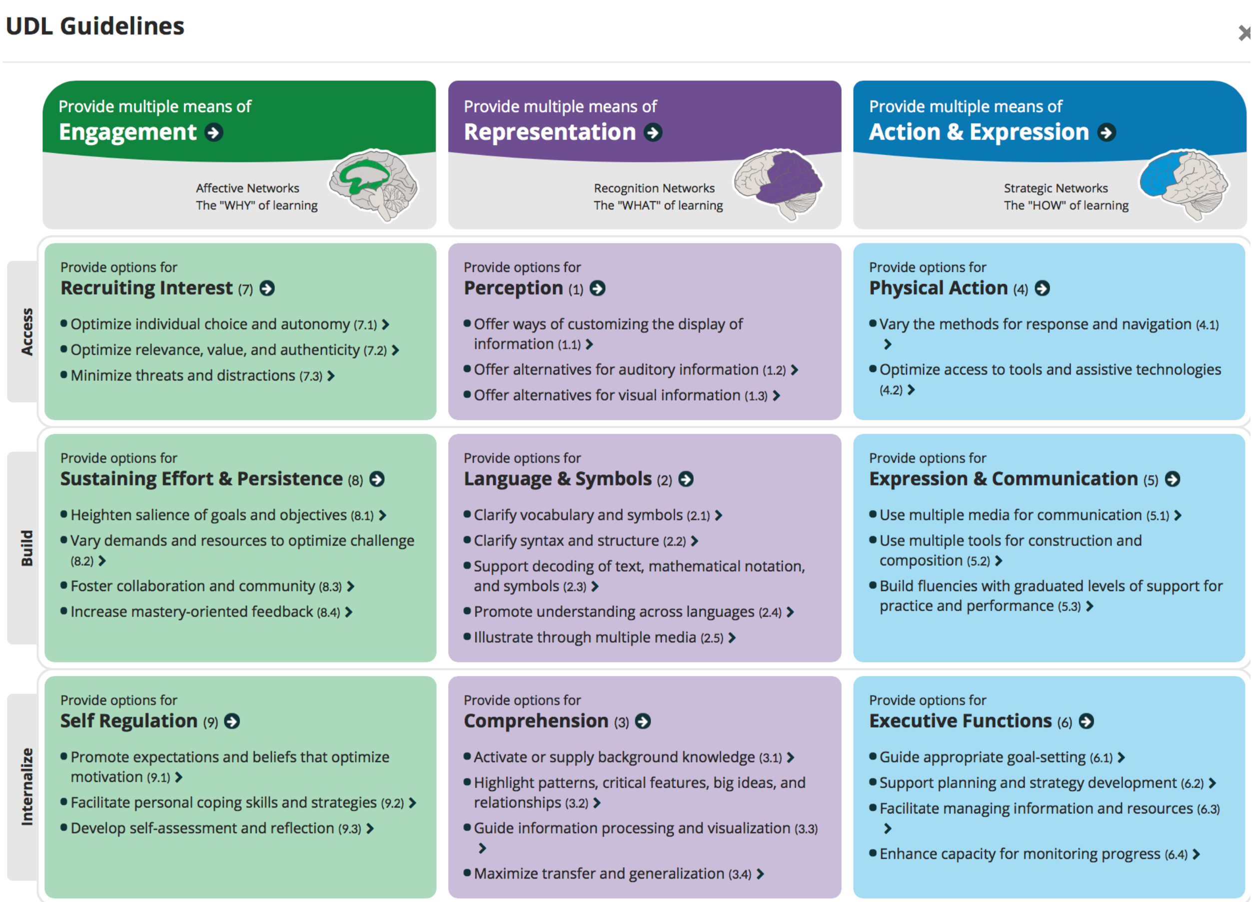

Figure 2 Universal Design for Learning (UDL) instructional design framework

With the guidance of the conceptual framework of UDL, the researcher intends to identify student learning needs through examining and understanding complex factors related to the success and persistence of SWDs in post-secondary STEM education. Many studies identified important factors, including the high demand of EF for SWDs in post-secondary STEM gateway courses (Parker & Boutelle, 2009), career knowledge about STEM professions (O'neal et al., 2007), student characteristics (Lee, 2011), and a supportive institutional climate (Street et al., 2012; Chen & Solder, 2013). For instance, positive interactions among peers and SWDs in a peer-led team learning (PLTL) model showed positive impacts on students with learning disabilities and attention deficit hyperactivity disorder (ADHD) when they worked collaboratively to improve their problem-solving skills (Street et al., 2012). Second, the guided framework will identify the research gap between practices supporting EFs and the integration of innovative technology tools (i.e., mobile phones and an application) to support EFs development for SWDs in post-secondary STEM. Third, the researcher adopted the guided framework to validate the design of the research-based practice and mobile applications to support EFs for SWDs in post-secondary STEM. With an empirical study to provide support to SWDs in STEM gateway courses through a mobile EF coaching solution, the researcher investigated the design of the mobile EF coaching support and its impact on EFs and learning outcomes. See Figure 1 to understand the TOC model used in this study. The researcher adopted a user-centered approach to design a mobile application with integrated EFs and learning strategies to support SWDs in complex learning contexts and to support EFs development for those students during their learning process.

This study investigated the insights of post-secondary STEM individuals with and without disabilities regarding their experiences with academic coaching through mobile phones and examined whether e-mentoring is effective in supporting the EFs of those students. In this study, the researcher adopted a parallel mixed methods study design (Hesse-Biber, 2010) to evaluate and improve innovative mobile learning environments and to upgrade instructional design using the affordances of mobile devices and applications to support the learning process. The study aimed to explore applicable solutions through investigating EF coaching based on the affordances of mobile technology tools.

With the adoption of a mixed methods study design, this research may help understand complex learning contextual variables to improve the theoretical accounts of teaching and learning and to explore the design of new learning environments via mobile devices. The study aimed to explore the educational innovation capacity to support SWDs' active learning and their success and persistence in post-secondary STEM education. Both deductive and inductive research was used in the research process. A mixed methods study was used to collect data on the learning experiences of SWDs using academic coaching via mobile application to explore how they interacted with the application and to measure whether the use of this application was related to changes in EFs among those students.

In summary, this study explored the integration of EF coaching with mobile technology tools and applications to satisfy individuals with diverse learning needs, especially SWDs, and to support their success and persistence in post-secondary STEM education. The mobile EF coaching solution study investigated the design of practicing EF coaching on a mobile platform with design-based research methodology to develop post-secondary support services for STEM SWDs. This study added to the limited but growing research on implementing EF coaching via innovative technology tools to support students' academic goals and performance.

Research Questions

1. What are the outcomes of participation in this mobile EF coaching solution for individuals with and without disabilities?
2. What features of the mobile EF coaching support are helpful or not helpful in supporting EFs?
3. What challenges do participants perceive in their post-secondary STEM gateway classes?
4. What differences do participants perceive between this mobile EF coaching solution and other types of support services in post-secondary STEM education?

Chapter 2

Review of Literature

This chapter provides a review of studies on SWDs in post-secondary STEM education and their EF challenges. It also reviews the types of EF support that have been researched to help those individuals in these settings. This chapter is divided into two sections. The first section provides an overview of SWDs and their challenges associated with EF in post-secondary STEM education. In the second section, summaries of two separate reviews are integrated. Specifically, the first review focuses on EF coaching solutions for SWDs in post-secondary STEM education. Next, to follow up on the implications and limitations from the first review, the researcher conducted the second review to understand studies on using mobile technology in supporting EF coaching for SWDs in post-secondary STEM education. The integrated reviews informed discussions on how to design the mobile EF coaching solution to support EFs during the learning processes. The chapter concludes by identifying targeted research needed to advance the understanding of supporting the EF of SWDs in post-secondary STEM education.

The Benefits of Post-Secondary Education and STEM for Individuals and Society

Studies continue to find that higher education is increasingly associated with a better-informed citizenry, better health, better caregiving and parenting skills, and higher job satisfaction, as well as continued economic benefits (Baum, Ma, & Payea, 2013). As noted by Ma, Pendar, and Welch (2016), the benefits of college degree attainment provide both monetary and non-monetary benefits to individuals. Data continually show that people who attained post-secondary degrees have more opportunities for meaningful and sustaining employment (U.S. Bureau of Labor Statistics, 2013). For instance, based on an economic analysis from the Pew Research Center (PRC) (2014) college graduates between the ages of 25 and 32 earned more annually in a full-time job (about $17,500 more) than employed young adults holding only a high school diploma. Recognizing these outcomes, the federal initiative “Pathways to Success” emphasizes the importance of higher education in the educational accomplishment of underrepresented populations (Advisory Committee on Student Financial Assistance, 2012).

However, not all areas of study in post-secondary education have the same occupational potential. Research on job market data found that a set of core cognitive skills, knowledge, and abilities related to STEM learning are in demand not only in traditional STEM jobs but also in almost all job markets (Rothwell, 2013). Furthermore, after an analysis of data from the Occupational Employment Statistics and Employment Projections, Fayer, Lacey, & Watson (2017) found that the national average wage for all STEM occupations is $87,570, which is nearly double the national average wage of $45,700 for non-STEM occupations. Data on STEM occupations and careers demonstrate a concentrated need to support more people in obtaining such knowledge and skills (Rothwell, 2013). It is thought that an increased demand for a STEM workforce may strengthen the national economy and maintain the nation’s leading global role in scientific and technological innovation (National Science Board [NSB], 2010). At the same time, these individuals, especially individuals with disabilities who developed advanced knowledge and skills in STEM, may have work-related opportunities that lead to a higher quality of life and increased workforce opportunities in STEM fields (Basham & Marino, 2010). Their participation may also diversify the workforce in STEM fields (Leddy, 2010).

Clearly post-secondary and STEM education are important to both individuals and society at large. Generally, an interdisciplinary understanding of STEM is critical to supporting an informed and democratic citizenry as well as a thriving global society (Basham, Israel, Maynard 2010). Provided these societal needs and changes, the modern economy has an increased demand for a diverse STEM workforce, including individuals with disabilities, women, and racial/ethnic groups with post-secondary and college degrees (NSB, 2010; NSF, 2015). Based on data from the U.S. Department of Labor (DOL) Office of Disability Employment Policy (ODEP) (2018), only 21.5% of individuals with disabilities are part of the national labor force, and only around 5% of the STEM workforce has an identified disability (Leddy, 2010). Given an increased need and decreased participation, Street et al. (2012) has argued that it is critically important to include individuals with disabilities in STEM fields, as historically they have already contributed to various areas of science, computer engineering, and mathematics. These data point to a need for larger and concentrated efforts in understanding and supporting the success of SWDs in post-secondary STEM education.

Individuals with Disabilities in Post-Secondary STEM Education

SWDs are just as likely as typically developing students to enroll in science and engineering fields in post-secondary education (Sutton, 2017). However, the presence of a disability can complicate an individual's opportunities of degree attainment and career development (Trammel, 2009). These complications often lead to higher dropout rates and lower graduation rates for SWDs in post-secondary STEM education compared to their peers without disabilities (Lee, 2011; Chen, 2012). When successful, SWDs take longer to graduate, which costs them more money to obtain a degree (Lee, 2011). There are many existing complex factors, as mentioned in Chapter 1, correlated with the success and persistence of individuals with disabilities in post-secondary STEM, including a student's characteristics, STEM courses and performance, pre-college experience, college experience, lab climate, and institutional structure (O'neal et al., 2007; Lee, 2011; Street et al., 2012; Chen, 2013).

Among the many complex challenges in degree completion, SWDs often struggle with performance and persistence issues in STEM gateway courses (Street et al., 2012; Chen, 2013; Bellman, Burgstahler, and Hinke, 2015). For instance, students tend to leave the STEM major if they withdraw or fail a STEM gateway course in their first year (Chen, 2013). Researchers further identified that the challenges in STEM gateway courses are often associated with the need for higher levels of EFs in order for students to be successful (Bellman et al., 2015; Street et al., 2012). EFs generally include various skills related to strategic planning, reasoning, problem solving, organized search, flexibility of thought and action, and initiation (Collins & Koechlin, 2012, Lunt et al., 2012). However, individuals with a range of disabilities may face EF challenges in their post-secondary STEM education. It is important to provide necessary support to improve EFs for student success in obtaining a college degree.

Supporting the Success of Individuals with Disabilities in Post-Secondary Education

Supporting success for all, especially SWDs in inclusive settings, helps students fully participate and progress in the general curriculum with conceptual and practical meaning (Morningstar et al., 2017). Currently, the existing challenge for many post-secondary disability service providers to include SWDs in post-secondary education primarily comes from the increasing enrollment of SWDs in post-secondary education along with expected annual budget cuts and a lack of resources (Cooper, 2015). Another challenge is from the unknown exact number of SWDs in each post-secondary educational setting due to the low self-identification rate of disability status (Hudson, 2013). Indeed, a recent study identified that only around 28% of students who received special education services in K-12 education disclosed their disability when they went to college, and only 19% stated that they have received any accommodations or supports in college (Newman, Wagner, Cameto, & Knokey, 2011). At the same time, the process for determining educational accommodations and services for individuals with disabilities in post-secondary education is undefined, not required, and differs greatly among educational programs (Stodden, Jones, & Chang, 2002; Harding, Blaine, Whelly, & Chang, 2006). Educational assistance and support are often decided by the type of the institution and its capability in each post-secondary educational setting (National Center for the Study of Post-secondary Educational Supports, 2000). Rather than having a unified and transparent system, researchers noted that the power to evaluate and execute disability accommodations remains with educational institutions (Heyward, 2011; Hudson, 2013).

The major difference between secondary and post-secondary educational settings is the method of identifying and accommodating SWDs and the funding source associated with this work (Stodden, Conway, & Chang, 2003). The Americans with Disabilities Act of 1990 (ADA, 1993) and Section 504 of the Rehabilitation Act ensure individuals with disabilities have access to higher education and protects them from discrimination based on their disability (Hudson, 2013). However, without the mandates of the Individuals with Disabilities Education Act (IDEA), individuals must self-identify as having a disability and must provide documentation of disability status to the post-secondary educational program to request accommodations and services (Stodden et al., 2003). The Americans with Disabilities Act Amendments Act of 2008 (Amendments Act), broadened the interpretation of disability and simplified the disability documentation and identification process for students (Heyward, 2011; Hudson, 2013). However, according to Hudson (2013), the ADA Amendments Act of 2008 does not specify and mandate post-secondary institutions to identify and provide various support and services to SWDs when they pursue their education (Hudson, 2013). With the challenges for post-secondary disability service providers to include SWDs, the existing literature identified that those students are in great need of EFs support for success in post-secondary STEM education (Parker & Boutelle, 2009; Bellman et al., 2015).

EF Challenges for Individual Academic Success in Post-Secondary STEM Education

EFs are defined as capabilities to manage complex goal-directed behaviors and purposeful tasks in daily life (Royall et al., 2002; Suchy, 2009). Diamond (2013) proposed a three-factor model of EFs in which inhibition, working memory, and cognitive flexibility work together to influence higher-order executive functions such as reasoning, planning, and problem solving. Studies have shown EFs are predictive of outcomes throughout life, including school academic achievement and workforce performance (Diamond & Lee, 2011; Borella et al., 2010; Duncan et al., 2007; Best, Miller, & Naglieri, 2011), physical health (Crescioni et al., 2011, Miller, Barnes, & Beaver, 2011; Riggs, Chou, Spruijt-Metz, & Pentz, 2010), quality of life (Brown & Landgraf, 2010; Davis, Marra, Najafzadeh & Liu-Ambrose, 2010), job success (Bailey, 2007), and marital harmony (Eakin et al., 2004).

From a developmental perspective, individuals develop EFs throughout adolescence to early adulthood (Bellman, Burgstahler, & Hinke, 2015; Romine & Reynolds, 2005). Associated with human performance, EF specifically impacts cognitive flexibility, appropriate action management, making and implementing plans, working memory, self-monitoring, and emotional and behavioral regulation (Grieve, Webne-Behrman, Couillou, & Sieben-Schneider, 2014). People with EF challenges encounter issues in multiple life domains and areas of functioning including academic, social, occupational, and psychological areas (DuPaul et al., 2009; Weyandt et al., 2013).

EF deficiencies present a significant barrier to success and persistence for SWDs in post-secondary STEM education (Bellman et al., 2015). In transitioning to and pursuing college studies in post-secondary STEM education, challenges include regularly indicating the struggle to manage time, make plans, complete assignments, organize tasks, and maintain or shift focus from one task to another (Parker & Boutelle, 2009). Individuals with a range of disabilities may face EF challenges in post-secondary education. For instance, most existing literature points out that individuals with ADHD and/or LD may experience various EF challenges in post-secondary educational settings (Parker & Boutelle, 2009). Those challenges include academic procrastination (Hen & Goroshit, 2014), a lack of adequate preparation in academic work, poor organization, difficulties with time management and study skills (DuPaul et al., 2017), and higher academic stress (Hyman, Arthur, & North, 2006). Studies also identified that the EF challenges for college students with ADHD and LD may lead to lower retention rates and diminished educational and occupational attainment compared to peers without disabilities (Murphy, Barkley, & Bush, 2002; Wagner, Newman, Cameto, Garza, & Levine, 2005). Students with Autism Spectrum Disorder (ASD) can also present with EF deficiencies (Goldstein & Naglieri, 2014). EF deficits challenge individuals who have injuries and illnesses associated with brain damage/lesions or other neurological worsening (e.g., traumatic brain injuries, stroke, Parkinson’s disease) and those with limitations in functioning and adaptive behavior (e.g., dementia, schizophrenia; Bak et al., 2008; Jurado & Rosselli, 2007; Krpan, Levine, Stuss, & Dawson, 2007).

Given the increased responsibility and autonomy required with less structure and support, the college experience is an important transitional stage for all students, but especially for SWDs with EF deficits (Parker & Boutelle, 2009; Estrada, Dupoux, & Wolman, 2006). It is important to consider and provide personalized support for college students who require assistance during these life transition periods (Grieve et al., 2014). Morningstar and colleagues (2017) noted the importance of support in inclusive transition settings. It was important to provide access to general learning support and strategies, i.e., providing learning strategies instruction across grade levels to prepare students for college and career readiness (Morningstar et al., 2017). However, there existed a huge gap between available customizable academic support and services from post-secondary educational settings and meeting the personalized needs of SWDs to be academically successful (Dunn et al., 2012).

Existing executive functioning support for students with disabilities. Researchers have begun to conduct research on EF to support students with ADHD, LD, and/or other types of disabilities in post-secondary education (Parker & Boutelle, 2009; Parker, Hoffman, Sawilowsky, & Rolands, 2011; Bellman et al., 2015; Robinson & Gahagan, 2010). Generally, EF support can be provided through academic coaching or EF coaching (Parker & Boutelle, 2009). In this work, academic coaching is a "one-to-one interaction with a student focusing on strengths, goals, study skills, engagement, academic planning and performance" (Robinson & Gahagan, 2010, p. 27). As a type of academic coaching, EF coaching is defined as "a specialty within the burgeoning field of personal coaching, and provides support for the development of skills, strategies, and beliefs needed to manage executive function challenges" (Parker & Boutelle, 2009, p. 205). Academic coaching emphasizes an "inquiry" model of asking rather than telling (Parker & Boutelle, 2009). In the coaching process, students can learn from the modeling of effective EF and develop their own ideas as their competence grows in clarifying, making realistic plans, and taking actions on goals based on increasing self-awareness of their thinking and actions (Parker et al., 2011). In many studies, the terms "mentoring" or "academic coaching" were used interchangeably (i.e., Koch, 2016; Single, Muller, Cunningham, Single, & Carlsen, 2005).

To understand the effectiveness of EF coaching support on the academic success and persistence of SWDs in post-secondary STEM education and the use of technology to provide EF coaching support, the author adopted the UDL framework to guide the review of the existing empirical studies on supporting EFs for those students in post-secondary STEM education. Specifically, this review is organized from the understanding of the empirical studies on EF coaching to support SWDs in post-secondary STEM education. After identifying the limitations of traditional EF coaching in the first review, the researcher then conducted a second review to understand the current studies on using technology in supporting EF coaching for SWDs. In total this literature review informed the research and design of a mobile EF coaching solution for SWDs in post-secondary STEM.

UDL Framework as the Conceptual Framework

Traditional supports for SWDs in post-secondary settings include (a) academic mentoring (e.g., peer-led team learning) (Street et al., 2012), (b) technology tools (Koch, 2016; Street et al., 2012; Hwang & Taylor, 2016), (c) academic counseling (professional perspectives) (Koch, 2016), (d) role models (Summers, 2009), (e) work-based learning experiences (Bellman, Burgstahler, & Ladner, 2014), (f) academic coaching (Bellmen, Burgstahler, & Hinke, 2015), and (g) e-mentoring (Single & Single, 2005).

As an emerging framework in inclusive higher education, UDL may provide a new way to consider design and support across post-secondary environments through bringing flexibility and creativity when delivering and managing instruction (Roberts, Park, Brown, & Cook, 2011). A recent survey from Educause (2018) identified accessibility and UDL as the second largest issue in teaching and learning in higher education. Morningstar and her colleagues (2017) noted that the UDL framework, as well as accommodations, adaptations, and modifications, can be explicitly identified to ensure supportive learning across settings. "At the heart of UDL is appropriate technology integration to provide supports for diverse learning needs" (Basham, Meyer, & Perry, 2010, p. 340). As an educational design framework focused on supporting the growth of learners, UDL considers the associated interactions among the learners, their goals, the environment, and learning experiences (Meyer, Rose, and Gordon, 2014; Israel, Ribuffo, & Smith, 2014). Through this perspective, UDL can help identify solutions for overcoming unnecessary barriers within the learning process (Meyer et al., 2014). From this perspective, traditional supports may not actually meet the needs of SWDs in post-secondary STEM settings. For instance, if a student is given the ability to take untimed exams, yet is not prepared to take the exam, then the accommodation is useless. This said, if EF is known to create a large barrier for SWDs in STEM courses, then a design solution should be put in place to help overcome that barrier.

This review aimed to provide a theoretical foundation for the design of EF coaching support on a mobile platform to support the persistence and success of SWDs in post-secondary STEM education. It is meaningful to identify a targeted research need to advance understanding the effectiveness of EFs coaching supports on the persistence and success of SWDs in STEM fields. The following section summarized the two separate reviews on the effectiveness of providing traditional EF coaching for SWDs in post-secondary STEM education and on the effectiveness of emerging technology in supporting the persistence and success of those students in post-secondary STEM education.

A Summary of EF Coaching for Students with Disabilities in Post-Secondary STEM Education

Search procedures. To locate peer-reviewed publications from 2000-2017, the following databases were searched: Google Scholar, Eric, and PsycINFO. The search terms included the combination of the words “executive functions coaching” and “post-secondary students with disabilities” or “mentoring” or “STEM” or “college” or “technology”. To narrow the field of literature to the studies most relevant for the purposes of this research, a set of selection criteria for inclusion in the review were established. The inclusive criteria were a) the research participants or subjects were students with disabilities, b) the educational setting had to be post-secondary STEM education or post-secondary education, c) empirical studies, and d) the research results showed the positive impact of EF coaching on academic performance or learning strategies of SWDs in a post-secondary institution and/or the degree completion of SWDs. Due to the paucity of existing literature on EF coaching to SWDs in post-secondary STEM education, the empirical studies that met all the inclusive criteria and occurred in any type of post-secondary STEM education or post-secondary educational settings were included in this review.

Selecting research articles for this review with the aforementioned criteria took three steps. First, Google Scholar was searched, yielding 174 articles. All 174 abstracts were reviewed with a focus on EF coaching/mentoring for SWDs in post-secondary STEM education. Upon the review of abstracts, the included articles were narrowed to a collection of 11 articles. Second, to confirm the findings on Google Scholar, the same methods were followed on the ERIC and PsycINFO databases. The search items included the combination of the words “executive functions” and “students with disabilities” and “coaching” or “mentoring” or “STEM” or “technology” or “college” or “post-secondary”. From the ERIC database, the researcher found 37 results. After reading the abstracts, the results were narrowed down to six articles from the ERIC database that met the inclusive criteria. However, only one article was included, as the other five overlapped with articles from the Google Scholar search results. From the PsycINFO database, the researcher found 34 results. However, only one article from PsycINFO database was found to be relevant, again overlapping with articles from the other two databases. Third, after the electronic search, an ancestral or bibliographic search was conducted involving the examination of the reference lists of each found article (Wolery & Lane, 2014). One more article was found and added. In total, 13 empirical studies met the criteria for further discussion in this study.

Among the 13 studies, 11 studies focused on EF coaching to work with SWDs in post-secondary STEM education (i.e., Parker & Boutelle, 2009; Parker et al., 2011). Two studies specifically focused on providing EF coaching SWDs in post-secondary STEM education (i.e., Street et al., 2012; Bellman et al., 2015). Regarding the participants in the 13 studies, 10 focused on students with ADHD and/or LD in post-secondary educational settings (i.e., Parker & Boutelle, 2009; Field, Parker, Sawilowsky, & Rolands, 2013) and three focused on students with different types of disabilities (i.e., Street et al., 2012; Grieve, Webne-Behrman, Couillou, & Sieben-Schneider, 2014; Bellman et al., 2015).

Research designs of the reviewed studies. The selected studies under review adopted various research designs. These included investigations employing uncontrolled case study designs (i.e., Swartz, Prevatt, & Proctor, 2005), qualitative designs with purposive sample interviews (i.e., Parker et al., 2011 & 2013; Mytkowicz & Goss, 2012), quantitative designs (i.e., Grieve et al., 2014) quasi-experimental pre–post with no control group design (Prevatt & Yelland, 2013), mixed methods designs (Field et al., 2013; Richman, Rademacher, & Maitland, 2014), and longitudinal study designs (DuPaul et al., 2017).

Results of the reviewed studies. In general, the studies under review found that EF coaching (and academic coaching) was associated with improved learning strategies and EFs including time management, problem solving, and stress management, as well as achievement of academic goals for college students with ADHD and/or LD and students with different disabilities in post-secondary education (Parker & Boutelle, 2009; Field et al., 2013; Grieve et al., 2014). For instance, Field and colleagues (2013) noted that academic coaching significantly improved study skills, learning strategies, and EFs in a mixed methods study. The investigation involved 160 college students with ADHD who were attending 10 different universities. Indeed, among the 13 reviewed studies, 10 examined academic and/or executive function coaching interventions for students with ADHD and LD in post-secondary education. The primary purpose of these studies was to evaluate the correlation between EF coaching and improved organization, management of tasks and associated stress, and educational functioning for students with ADHD and/or LD in post-secondary education. Many studies also focused on identifying student perceptions of the impact of ADHD coaching on their academic success and broader life functioning to increase self-awareness and EF perception during learning (Parker et al., 2013).

Other studies reported positive outcomes such as growth in self-authorship and self-determination, greater metacognitive awareness, improved academic skills, and changes in their perceptions of themselves as learners and their learning differences (i.e., Mytkowicz & Goss, 2012; Parker & Boutelle, 2009; Parker et al., 2013). For instance, Parker & Boutelle (2009) identified that coaching primarily supported emerging autonomy compared to traditional services for college students with ADHD and/or LD in post-secondary education. Parker & Boutelle (2009) also found that coaching helped students develop and manage their EFs and improved their self-efficacy and confidence about academic success. In addition, researchers indicated that students improved their goal attainment skills through coaching by (a) framing goals more realistically, (b) generating more specific goals, (c) considering their goals more often, and (d) maintaining a desire to reach their goals (Parker et al., 2013).

Research suggested that mentoring or academic coaching may be a key strategy for supporting educational persistence, including within STEM, for SWDs (Gregg et al., 2016). Specifically, the existing literature on EF coaching mostly focused on its impact on students' academic outcomes, learning and study strategies, self-regulation, and subjective well-being, especially for college students with ADHD and/or LD (i.e., Field et al., 2013; Parker et al., 2011). Those studies primarily aimed to improve those student's competence to manage the cognitive processes involving planning, organizing, strategizing, paying attention to details, and managing time (i.e., Bellman et al., 2015).

Unfortunately, only a few studies focused on providing EF coaching or mentoring to SWDs in post-secondary STEM education. Bellman and colleagues (2015) conducted research on students with a wide range of disabilities who participated in the AccessSTEM academic coaching pilot initiative. This study was funded by NSF. The findings suggested that students with a variety of disabilities can benefit from coaching relationships, which increased their capacity to manage the cognitive processes used in planning, organizing, strategizing, paying attention to details, and managing time (Bellman et al., 2015). Street et al. (2012) received support from a NSF grant to adapt the Peer-Led Team Learning (PLTL) model by incorporating the Principles of Universal Design for Instruction (UDI) into the peer mentors' training for individuals with disabilities who were interested in pursuing a STEM careers and taking introductory STEM courses. Findings showed MPLTL helped those students persist in STEM coursework at higher rates than at pre-intervention (Street et al., 2012). In addition, those students grew most in the self-regulation skills cluster between pre- group and post-group test results (Street et al., 2012).

Metacognition and learning strategies. The existing literature showed that EF coaching support provided instruction and modeling in metacognitive strategies to help students improve EFs such as planning, reflecting, monitoring, evaluating, and developing self-awareness about EFs in their learning (i.e., Mytkowicz & Goss, 2012; Bellman et al., 2015). While metacognition is an important component of the learning process for college students, the development of meta-cognitive knowledge and regulation is particularly important for students with LD and/or ADHD (Mytkowicz, Goss, & Steinberg, 2014). However, there are few studies that focus on providing EF coaching support to SWDs to develop those learning strategies in post-secondary STEM gateway courses. These studies identified the process to build metacognition strategies that help students develop knowledge about learning, self-awareness as a learner, effective learning strategies, and the competence to monitor and regulate one's thinking and learning (Borkowski, Chan, & Muthukrishna, 2000; Pintrich, 2002). It is important to conduct research on providing EF support and service for the success and persistence of SWDs in completing their degree in STEM education.

Limitations and implications. This was not to say that coaching was not without some concerns. The ability to scale and financially support a one-to-one program across an entire university campus can be prohibitive. A campus that adopted such a model was Landmark College, a two-year post-secondary institution with a special educational setting in Putney, Vermont. Landmark, a private school, exclusively focused on providing individualized direct service to support learners with special needs, especially those with ADHD and LD, and related learning disorders (Parker & Boutelle, 2009). A good deal of their success was noted to be associated with their one-on-one supports and coaching model to all enrolled students (Parker & Boutelle, 2009). As an outcome, they were successful at graduating students; however, the financial support for these services was prohibitive. For multiple years, Landmark has been identified in many news reports as one of the most expensive colleges in the U.S. (i.e., Labosco, 2015; O'shaughnessy, 2011).

Use of Online and Mobile Technology to Provide Coaching Support Solutions

Online and mobile technology can provide coaching to SWDs with immediate feedback and less cost in time and money, potentially expand access opportunities to STEM courses, and support the active learning of SWDs for their advanced education and STEM professions. Online mentoring (electronic mentoring or e-mentoring) was identified as one effective practice to support the success and persistence of SWDs in STEM majors (Gregg et al., 2016; DO-IT, 2007; Burgstahler & Crawford, 2007). As forms of coaching, e-mentoring generally included the provision of online learning and training practices, access to virtual environments, use of social media platforms to promote networks of support, and virtual linkage to learning resources (Gregg et al., 2016; Wolfe & Gregg, 2015).

The research on providing coaching support through emerging technology tools showed great potential in supporting students learning. E -mentoring was an appealing option for mentors and mentees because of its convenience in terms of time and location and its low cost once a connection is established (Burgstahler & Cronheim, 2001; Sword & Hill, 2002; Burgstahler & Crawford, 2007). For instance, with a focus on supporting the persistence and success of students with LD and ADHD in post-secondary STEM education, Marino et al. (2016) conducted exploratory studies to identify effective leaning strategies to support the success of those students through mobile devices in the iCAN project at the University of Central Florida. The two-year iCAN project, funded by the NSF, aimed to provide interdisciplinary coaching to support undergraduates in STEM. The graduate student-coaches indicated positive gains in their ability to use coaching skills with their students in K-12 classrooms, and the coaching skills allowed post-secondary students with disabilities to persist in STEM gateway courses (Parson, 2017; Koch, 2016; Marino et al., 2016).

Considering the potential of using mobile technology to support coaching for SWDs in STEM education, it is necessary to examine the existing literature on how to provide EF coaching support with an integration of technology tools. For a better understanding of the effectiveness of EF coaching support through mobile technology tools on the success and persistence of individuals with EF challenges, the researcher then conducted a review of the current studies on using mobile technology to support EF coaching/mentoring for SWDs in post-secondary STEM education.

Studies on Technology-Based EF Coaching/Mentoring in Post-Secondary STEM Education

Search Procedures

To look for peer-reviewed publications from 2000-2017, databases including Google Scholar, Eric, and PsycINFO were used. The search items included the combination of the words "technology" and "post-secondary students with disabilities" or "STEM" or "EF coaching" or "academic coaching" or "e-mentoring". First, Google Scholar was searched, and 44 articles were found. The search yielded three articles after the researcher read the abstracts and titles. Second, Eric was searched, 87 articles were found, and the search yielded one article after the researcher read the abstracts and titles. Third, a search on PsycINFO yielded 19 articles, and none of those articles were related to online coaching or e-mentoring after the researcher read the abstracts and titles. Altogether there were only four empirical studies under review, all of these four studies were funded by NSF grants to support the persistence of under-represented SWDs engaged in STEM learning and career transition. One goal of the NSF is to search for sustainable solutions for increasing STEM retention in students with disabilities. There are no empirical studies on designing or implementing EF coaching on mobile technology platform for SWDs in post-secondary STEM education.

With there were emerging studies that examine the effectiveness of EFs support and service on SWDs in post-secondary STEM education, there was a lack of empirical studies that investigated providing EF coaching for those students with emerging technology in post-secondary STEM education. Surprisingly, as early as 1992, DO-IT (Disabilities, Opportunities, Internetworking, and Technology) founded its e-mentoring community to facilitate peer and mentor support for the purpose of promoting the successful transition of SWDs into challenging academic and career fields (DO-IT, 2007; Burgstahler & Crawford, 2007). However, the researcher only found three studies (i.e., Burgstahler & Crawford, 2007; Todd, Moon, & Langston, 2016; Gregg et al., 2016) with a focus on e-mentoring in supporting the educational persistence of SWDs and one study (i.e., Gregg et al., 2017) that investigated the effectiveness of virtual mentoring for enhancing the persistence of secondary and post-secondary SWDs engaged in STEM learning.

Results of the reviewed studies. The selected studies showed e-mentoring as one effective practice for supporting the retention, persistence, and graduation of under-represented post-secondary SWDs in STEM majors (i.e., Gregg et al., 2016; Burgstahler & Crawford, 2007). For instance, Gregg and colleagues (2016) conducted a qualitative study to examine the efficacy of e-mentoring for SWDs in post-secondary STEM education in a five-year, multi-institutional project. They identified that the practice of e-mentoring improved STEM learning and emotional supports, and e-mentoring programs created an opportunity to take a more inclusive, holistic approach to student success (Gregg et al., 2016). Gregg, Galyardt, Wolfe, Moon, & Todd (2017) investigated the effectiveness of virtual mentoring for enhancing the persistence of secondary and post-secondary SWDs engaged in STEM learning through an online survey. The findings indicated the most significant improvement was in students' perception of self-determination and self-advocacy after virtual mentoring practices (Gregg et al., 2017).

Features of e-mentoring. Identified advantages of e-mentoring included: (a) access to mentors with fewer constraints from time and space than face-to-face mentoring, (b) low cost, and (c) equalization of status and decreased stereotype threats (Ensher, Heun, & Blanchard, 2003; Gregg et al., 2016). Disadvantages of using e-mentoring included: (a) difficult non-verbal communication, (b) developing relationships online, (c) higher requirement of written communications skills, and (d) potential technology barriers (Ensher and colleagues, 2003; Gregg et al., 2016).

Technology tools used in e-mentoring. Multiple forms of technology tools were used during virtual-mentoring sessions, including digital voice communication platforms (e.g., Second Life [SL] voice, smartphones, video calling) or text-based communication platforms (e.g., email, social media posts, SL chat posts, text message conversation threads) (Gregg et al., 2017). Beyond virtual worlds, extensive social networking tools were broadly used, including Short Message Service (SMS), generally known as "texting," Skype (video plus audio), email, audio telephone calls, and Facebook (Todd et al., 2015).

Limitations and implications. Along with EF coaching, mobile technology has received great attention in research and practice to support active learning in formal and informal K-16 educational environments since the advent of the iPhone in 2007 (Duncan-Howell & Lee, 2007; El-Hussein & Cronje, 2010; Park, 2011; Xie, Basham, Marino, & Rice, 2017). M-learning refers to learning that happens when the learner was not at a fixed location or learning that occurs when the learner makes good use of learning opportunities through mobile devices with a connection to the Internet (O'Malley et al., 2003). M-learning can change the way we teach and learn. M-learning has many features, including being personalized, learner-centered, situated, collaborative, ubiquitous, and promoting lifelong learning (Sharples, Taylor & Vavloula, 2005). The increase of mobile technology tools that specifically target individuals with disabilities means broadened access to new tools and a greater need for developing appropriate supports for educational service providers and students with diverse needs (Ayres, Mechling, & Sansosti, 2013). However, research on how to use mobile technology to support learning for SWDs is in its infancy (Cumming & Rodriguez, 2013).

It was necessary to understand the ways in which M-learning has been tailored to students with diverse learning needs in consideration of learning contexts (Xie et al., 2017). The concepts for designing instruction in a learning context were identifying learner needs, learning materials, and technology like mobile devices (El-Hussein & Cronje, 2010). Scholars argued that the appropriate supports and environmental conditions ensured access to digital environments, where learners with disabilities showed strengths that would otherwise go unnoticed (Basham, Stahl, Ortiz, Rice, & Smith, 2015). Kwon & Lee (2010) noted mobile technologies innovate traditional learning environments into spaces that are more ubiquitous, connected, personalized, and supportive of the formation of self-directed learning communities. Reports of the successful integration of mobile technology were plentiful in many studies, but little support existed in the professional research literature for the use of mobile devices to support SWDs with a consideration of learning contexts, especially in post-secondary STEM education.

Draper Rodrı´guez, Strnadova´, and Cumming (2014) noted that mobile technology supports are just in the beginning stages of research, design, and integration for individuals with disabilities in educational settings. Based on the potential of mobile devices to support learners with disabilities (Xie et al., 2017) and the limited research in mobile coaching, it was thought that conducting preliminary research on the use of these devices to provide EF coaching is warranted. This study aimed to research the meaningful incorporation of academic coaching and technology tools to satisfy diverse learning needs of SWDs in post-secondary STEM education.

The Purpose of the Study

Existing literature showed the effectiveness of EF coaching for SWDs in post-secondary education, and a few studies attempted the integration of EF coaching into technology platforms to support learning. However, few studies focused on providing EF coaching support and developing those learning strategies for SWDs in post-secondary STEM education. Few studies focused on providing EF coaching through technology platforms. Therefore, this study aimed to address those limitations and to add to the literature in this critical area. Guided by the conceptual framework of UDL (CAST, 2011), the purpose of this study was to examine the design of mobile EF coaching solution to support EFs for SWDs in post-secondary STEM education through meeting their personalized learning needs. Specifically, one purpose of the mobile EF coaching solution study was to understand post-secondary STEM students' insights about their learning experiences with EF coaching through mobile phones and to investigate the design of EF coaching on a mobile application for individuals with disabilities in STEM gateway courses. The second purpose of this study was to develop EF learning strategies that can be deployed via mobile technology tools for STEM classes. In the design of a mobile EF coaching solution package, the researcher considered the combination of a goal-setting model (i.e., The Self-Determined Learning Model of Instruction by Shogren, Wehmeyer, Burke, & Palmer in 2017) and meeting personalized learning needs through this mobile EF coaching solution for individuals with diverse needs in post-secondary STEM education.

Chapter 3

Methodology

As discussed in previous chapters, SWDs tend to demonstrate challenges in EF skills that impact their performance and persistence in STEM gateway courses (Bellman et al., 2015). STEM gateway courses are the initial post-secondary courses (e.g., mathematics, chemistry, biology, physics) in STEM areas that are critical to post-secondary success (O'neal et al., 2007). This study investigated a mobile EF coaching solution and associated strategies for post-secondary students in STEM gateway courses. With a focus on improvement, a parallel mixed methods design study was adopted to answer the research questions. Indicated by existing literature, the coaching model consists of a goal-setting model from The Self-Determined Learning Model of Instruction (Shogren et al., 2017) and time/assignment management skills (Parker & Boutelle, 2009; Marino, Vasquez, Koch, Fisher, & Banerjee, in review) in this study. The researcher intended to answer the following research questions:

1. What are the outcomes of participation in this mobile EF coaching solution for individuals with and without disabilities?
2. What features of the mobile EF coaching support are helpful or not helpful in supporting their EFs?
3. What challenges do the participants perceive in their post-secondary STEM gateway classes?
4. What differences do the participants perceive between this mobile EF coaching solution and other types of support services in post-secondary STEM education?

In this study, the design process aimed to raise awareness of integrating mobile technology tools and to improve the transitional practice of supporting EFs and learning strategies for SWDs in STEM gateway courses in order to meet desired learning outcomes. The primary purpose of this study was to upgrade EF coaching design supports through a rigorous design process. Backwards design (Wiggins & McTighe, 2005) was applied in this study, with a focus on the desired learning outcomes and a feasible problem solution rather than just on the availability of technology tools in the learning environment (Basham, Meyer, & Perry, 2010). The desired learning outcomes in this study were improved EFs of students who were struggling in post-secondary STEM gateways classes. Another purpose of the study was to evaluate and improve innovative mobile learning environments. Both deductive and inductive research with a mixed methods study was used in the study. EF issues served as a way of viewing both initial problem areas and outcomes in this study. Please see Figure 3 for the conceptualization of the design process in this study based on the steps of the design process.

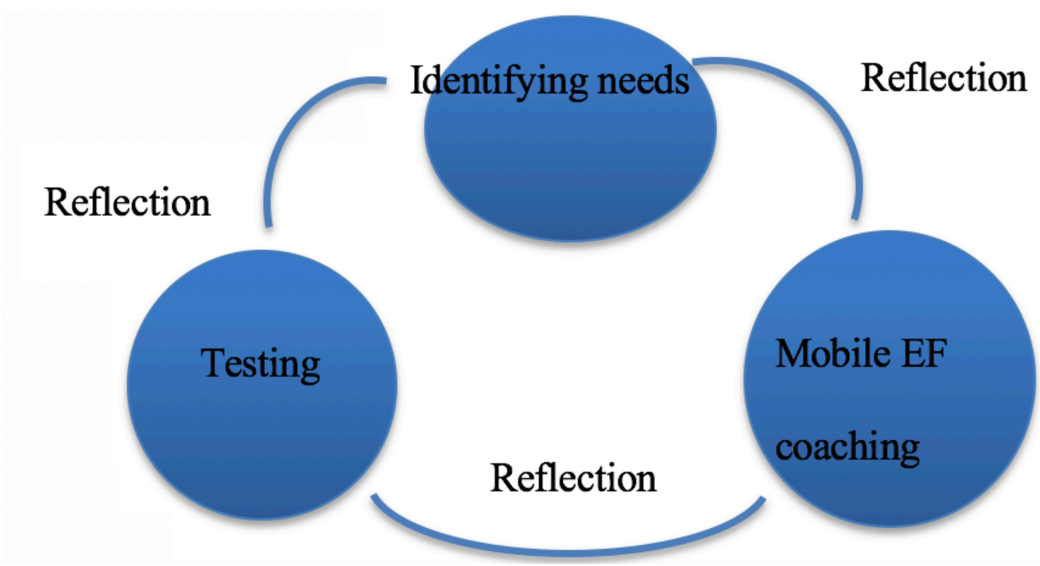

Figure 3 Conceptualization of the design process in this study based on the steps of the design process (Reeves, 2006; Plomp, 2010).

Research Design

A mixed methods approach was used to collect data to understand the individual learning experience of using EF coaching via a mobile application, to explore the process and user feedback of how students interacted with the application, and to measure whether the use of this application was related to the improvement of students' EFs. This study used a parallel mixed methods research design (Teddlie & Yu, 2007; Kemper, Stringfield, & Teddlie, 2003). Researchers identified that a parallel mixed methods research design is "currently one of the most common forms of mixed methods designs used in quantitative approaches to triangulate, or corroborate, a specific research finding" (Bryman, 2008, p. 93). The design of mixed methods research studies often uses qualitative and quantitative data collection and analysis techniques simultaneously or sequentially (Teddlie & Tashakkori, 2003). Creswell, Clark, Gutmann, & Hanson (2003) defined a mixed methods study as "involv[ing] the collection or analysis of both quantitative and/or qualitative data in a single study in which the data are collected concurrently or sequentially, are given a priority, and involve the integration of the data at one or more stages in the process of research" (p. 212). As indicated in the literature, social phenomena are very complex, so it was necessary to have different kinds of methods to best understand these complexities (Greene & Caracelli, 1997). Many scholars (i.e., Datta, 1997; Howe, 1988; Tashakkori & Teddlie, 1998) have argued that pragmatism was a paradigm that best validated the use of mixed methods research.

With the use of a parallel mixed methods design, the concurrent mixing of qualitative and quantitative methods was implemented as separate studies within the same research project (Hesse-Biber, 2010). The mixing happened during the data analysis and interpretation phase of the project in this study. Both the qualitative and the quantitative method can play a similar important role in gathering descriptive information in a parallel mixed methods study (Hesse-

Biber, 2010). The integration of the qualitative approach in the design of the study provided the capacity for generating detailed descriptions of human experiences (i.e., beliefs and behaviors) in the investigation within the original context in which observations took place (Guba & Lincoln, 1994). Guided by research questions, the researcher consciously compared and contrasted the research findings from both qualitative and quantitative datasets to connect the different data points. The use of research findings from both datasets provided an opportunity for the researcher to rethink the research objectives and to address different aspects of the research problems (Hesse-Biber, 2010).

Participant recruitment. Upon approval from the Institutional Review Board (IRB), the participant recruitment process lasted from November 27, 2017 to January 20, 2018. The recruitment activities included visits to several offices who provide services and support to students on campus, designing and redesigning participant recruitment flyers, posting flyers in multiple locations, attending dissertation workshops for tips on how to recruit participants on campus, and introducing the study during lab sessions for computer science courses. Please see Appendix E for the recruitment flyer. Within this process the following offices were visited: Student Access Services (AAAC), Trio, ADA Resource Center for Equity & Accessibility, Kansas Algebra Program (KAP), and the School of Engineering. It took two weeks to receive feedback and support from the KAP office to send the announcement of this study to freshmen and sophomores in STEM gateway mathematics courses. The AAAC office and ADA Resource Center for Equity & Accessibility responded quickly; however, it was difficult to get students with disabilities to respond to the study and to provide them with academic support. The recruitment email was sent out through the above mentioned offices three times to recruit participants. Please see Appendix F for the recruitment email information and consent letter to students. With a deadline of spring graduation, recruitment of participants ended the second week of Spring 2018.

Participants. The participants were first or second-year students in STEM-related classes who were in or wanted to study STEM related majors. The data used in this study were collected at a Midwest research-focused university sample in the United States between January 2018 and April 2018.

The researcher used a parallel mixed methods sample technique (Teddlie & Yu, 2007; Kemper, Stringfield, & Teddlie, 2003) to recruit participants who were taking STEM gateway mathematics courses at a Midwest research-intensive university in the United States during the 2017-2018 academic calendar. Participant recruitment lasted from November 2017 to January 2018. By the end of January 2018, the researcher received a recruitment response from 17 students with and without disabilities who were taking STEM gateway course (i.e., mathematics) at that university. During the pre-test, the Barkley Deficits in Executive Functioning scale (BDEFS) (Barkley, 2011) and learning strategies scale LASSI (Weinstein & Palmer, 2002) were used to measure the levels of EFs and learning strategies skills of those students. Among those 17 students with and without disabilities taking STEM gateway courses who responded to participate in the study during the recruitment process, three students did not participate in the first training meeting, two students withdrew from the study after the first training meeting, and another two students withdrew from the study after the first coaching session. Three students were only interested in participating in Part 1 of the study. In the end, altogether there were seven students with and without disabilities who participated in both Part 1 and Part 2 of the study. Those seven participants showed different levels of challenges with EFs and learning strategies in the pre-test results on the BDEFS and LASSI scales. Incentive to participate in the study included that participants received a $10 gift card if they were solicited upon completion of Part 1 of the study. Seven participants who completed both Part 1 and Part 2 in the intervention received a $30 gift card as compensation for their time. Please see Table 1 for participant recruitment information.

Participants had baseline technology knowledge to participate in this study. Specifically, they had experience using applications on mobile devices. Mobile devices may refer to an iPad or mobile phones. Each student was required to have their own mobile device. The mobile application of WhatsApp was used in the study.

Table 1

Participant Recruitment Information

Students	Number	%
Students who participated in the entire study	7	41.2%
Students who only participated in Part 1	3	17.6%
Students who responded to participate, but did not participate in the training session	3	17.6%
Students who withdrew from the study after the training session	2	11.8%
Students who withdrew from the study after the first coaching session	2	11.8%
Total response	17	

A total of seven participants, who each showed challenges with EFs on the BDEFS and LASSI scales, completed the mobile coaching study. All seven participants completed the two training sessions. Five participants (71.4%) received all six coaching sessions, and two participants (28.6%) received five coaching sessions with one coaching session missing. The training sessions included a pre-test session and a session on how to use WhatsApp and set up academic goals with a goal attainment scale.

In the following six weeks of coaching sessions, the researcher and the participants adopted the same design-based package in each coaching session. There were six female participants and one male participant. Two participants had identified disabilities and were receiving accommodations and services. One participant self-identified that she is taking pills to control her anxiety disorder on a regular basis. All three students completed six coaching sessions. The ages of the participants ranged from 19 to 30 years old. See Table 2 for detailed demographic information of the participants in this study.

Table 2

Participant Demographic Information (n= 7)

Characteristics	Variables	N	%
Ethnicity	Asian/Pacific Islander	1	14
	Hispanic	1	14
	White	3	43
	African-American	2	29
Disability	SWDs	3	43
	SWODs	4	57
Year	Freshman	4	57
	Sophomore	1	14
	Junior at KU, who are a sophomore in STEM majors	2	29
Age	18-19 years old	3	43
	20-29 years old	3	43
	30 years old	1	14
Gender	Female	6	86
	Male	1	14

Setting. The Midwest research-intensive university used in this study was a major public research and teaching institution in the United States with a student enrollment of 28,447 with almost equal proportion of women and men. The students were from all 50 states and 105 countries and are about 15% multicultural. Among its five campuses, this study was conducted on the main campus. On the main campus, there were around 2,000 students with and without disabilities in STEM gateway courses (i.e., mathematics) every semester at that research-focused university. In total, there were 935 self-identified students with disabilities who had registered at the students with disability service office on campus. Among those students, there were 416 males with disabilities and 517 females with disabilities across different majors. Among those students, 304 had two or more disabilities. At the time of the study, the number of students with disabilities taking STEM gateway classes was around 95.

Initial Design of the Mobile EF Coaching Package

As highlighted in Table 3, the coaching package comprised of a student's mobile phone, the use of WhatsApp, integrated videos, PDF documents, Word documents, and a weekly video/audio/message session between the researcher and the individual. Students were to receive a response to any inquiry to the coach within one day (24 hours). Participants were able to request and choose one of the tools (i.e., audio conference, video conference, text) to receive the coaching based on their preference. Participants had the chance to ask for learning strategies from the mobile EF coaching package during each coaching session. Every session started with goal setting and evaluating goal attainment. Then, based on participants' requests, one learning strategy was coached during that session. The researcher walked participants through strategies and helped them apply these strategies to the learning process. The complimentary document to that learning strategy was also delivered through WhatsApp (i.e., YouTube video, PDF document, or Word document). In each session, when students indicated issues with EFs in their learning processes, they received personalized learning strategies from the design coaching package. Personalized learning strategies in this package refer to the identified learning strategy with research evidence that was used in each coaching session based on learners' individualized needs.

Use of WhatsApp. The researcher made the decision to use the WhatsApp application due to its simplicity, flexibility, less restraint with time and space, low cost, and privacy features. Over the last two years, the application has become very popular, gaining over 350 million users, and was rated the most downloaded application in 127 countries (Cohavi, 2013). There are around 31 billion messages sent through WhatsApp daily (Tzuk, 2013). The simple operation scheme made the program accessible to a variety of people across ages and backgrounds with diverse needs (Bouhnik & Deshen, 2014). WhatsApp functioned across different phone operating systems (i.e., Apple, Android). One of the main benefits of WhatsApp was its simplicity (Bouhnik & Deshen, 2014). With the portability and mobility functions of mobile devices, the study on mobile learning demonstrated strong implications for the research and practice of mobile technology in existing literature (El-Hussein & Cronje, 2010). It has been widely recognized that mobile learning happens across contexts and technology devices (Walker, 2006).

Just-in-time feedback. The design of providing EF coaching support through a mobile application may have the following features. A primary design of mobile applications was to provide a feature of just-in-time feedback. The high availability of instructors to interact and provide immediate feedback to students' questions can potentially improve the learning process (Bouhnik & Deshen, 2014). The mobility feature of mobile devices may overcome the disadvantages of face-to-face coaching. The concepts of mobility referred to the mobility of technology, the mobility of the learner, and the mobility of learning in education (Sharples, 2013; El-Hussein & Cronje, 2010). Flexibility regarding the time and space to provide coaching support may make it possible to meet personalized needs and to provide immediate feedback.

Multimedia and multimodal computer-mediated communication. Computer-mediated communication (CMC) is defined as the use of networks of computers to facilitate interaction between spatially located individuals (Jonassen, Davidson, Collins, Campbell, & Haag, 1995). CMC facilitates constructivist learning and individualized learning featured with student-centered learning (Muir-Herzig, 2004; Guzley, Avanzino, & Bor, 2001). CMC can provide valuable alternative spaces for collaboration, communication, and opportunities for learner autonomy to support reflective and experiential processes (Simpson, 2002). Meaning making was the goal of the learning process (Jonassen et al., 1995). Many researchers argued that learning that happened during the process of solving real-world problems was much more meaningful and better understood because of the consideration of learning context through CMC (Jonassen et al., 1995; Simpson, 2002).

CMC in both asynchronous and synchronous forms, together with the possibilities of interactive media through the Internet, can provide access and availability for a wide range of learning opportunities (Simpson, 2002). For instance, in a study that investigated communication through M-learning tools in Norway, survey results showed that students considered SMS as a proper tool in learning with positive findings (Divitini, Hargalokken, & Norevid, 2002). As a communication app, WhatsApp facilitates the exchange of instant messages, pictures, videos, and voice calls via an Internet connection. For example, a built-in camera can help participants capture and share some special moments of activities. Current location information can be shared with friends and peers. In addition, most personal moments and information can be shared through WhatsApp without security concern issues because an end-to-end encryption has been built into the latest versions of the app (WhatsApp, 2018).

Personalized learning needs. Researchers have stated that learner variability was developmental, systematic, and context-dependent based on learning sciences (Fischer & Bidell, 2006; Rose & Fischer, 2009; Rose & Gravel, 2010). The consideration of an individual's background preparation, their learning situated in educational settings, and their learning based on age and development was important to understand diverse learning needs (Rose & Fischer, 2009). The design of learning goals, learning strategies, materials, and assessment tools was done in consideration of UDL principles to improve learning and learning outcomes (Hitchcock & Stahl, 2003; Rose & Strangman, 2007).

The researcher coached different learning strategies based on each learner's needs. With one's phone's Internet connection, the information can be expressed and represented in multiple means via text messages, images, and WhatsApp voice and video calls. Two coaching activities were designed to support EF skills and learning strategies development in this design coaching package. The following part introduced the learning strategies designed in the design coaching package.

Strategies during Coaching Sessions

As was justified in the literature review (Chapter 2), the coaching activities chosen and designed in the design coaching package were used across the six coaching sessions in Part 2 of the study. The learning strategies in the coaching activity were research-based practices to support EF skills, including 1) Activity 1: goal setting based on Self-Determination Learning Model of Instruction (SDLMI) goal setting procedures (Shogren et al., 2017) and goal attainment scaling were developed to implement the intervention, to evaluate the progress, and to compare the outcomes (Carr, 1979; Shogren, Palmer, Wehmeyer, Williams-Diehm, & Little, 2012); and 2) Activity 2: using a digital calendar to organize assignments and time (Prevatt & Yelland, 2015).

In this coaching package, the researcher adopted the SDLMI (Wehmeyer et al., 2000). This model of instruction was based on the principles of self-determination that enabled teachers to teach students to employ self-regulated problem-solving strategies to achieve self-selected goals using student-directed instructional strategies (Shogten et al., 2012). Many studies have shown very reliable effects among participants who received instruction using the SDLMI and met or exceeded teacher expectations for goal attainment (Shogten et al., 2012; Agran, Cavin, Wehmeyer, & Palmer, 2006; Wehmeyer, Palmer, Agran, Mithaug, Martin, 2000). The goal setting process can improve student learning and motivation (Zimmerman, 1990; Schunk & Zimmerman, 2012). In a recent functional magnetic resonance imaging (fMRI) study, Lee & Reeve (2012) identified that the self-determined behavior of goal setting was closely related to people's sense of agency and correlated with increased intrinsic motivation. The features of meaningful goals included being specific, measurable, achievable, relevant, and defined with a timeline for completion (Meyer, 2003; Michigan State University Extension, 2012). Time management referred to "the process of helping an individual manage actual and potential temporal commitment" (Myers, Berry, Blythe, Conley, et al., 2007, p. 47). Time management primarily focused on scheduling meetings or appointments, and it also included how to build reminders and balance workload (Myers et al., 2007). Assignment management was on planning, organizing, and executing assignments effectively based on time management (Parker & Boutelle, 2009). Please see Table 3 for the designed coaching activities.

Table 3

EF coaching support activities and structured protocols

	Goals	Activities
Activity 1	Setting academic goals	(1) Self-assessment: goals, interests, and motivation; (2) setting goals

Activity 2	Using a calendar to organize assignments and time	(1) Assignment management (2) Time management

Here is a brief description of the instructions for Activity 1 and Activity 2 in this design coaching package. In Activity 1, participants were asked to set up one or two specific academic goals that they would work on during the semester. Their goal setting process was guided by open-ended questions in the SDLMI model (Shogren et al., 2017). Participants were asked to share one or two academic goals that they planned to achieve that semester and revisited the developed goal attainment scale (GAS) (Shogren et al., 2012; Ruble et al., 2012). Please see Appendix G for goal setting with open-ended questions in the SDLMI model.

In Activity 2, participants were coached to use a calendar to organize assignments and time (Prevatt & Yelland, 2015). In the assignment management activity, participants were asked to complete the following activities through a mobile application: 1) identify all daily/weekly assignment lists, 2) set schedules, 3) organize assignments, and 4) set up reminders to complete homework assignments. In the time management activity, participants were asked to complete the following activities through a mobile application: 1) use a calendar, 2) make reminders, and 3) keep appointments.

Measurement Instruments

There were two major measurement issues related to EF skills (Barkley, 2011). These EF measurement issues included the absence of common measures of EF for participants across a wide range of ages and the absence of measurement to capture and measure the vast experience of participants across diverse settings and situations (Barkley, 2011; Carlson, Zelazo, & Faja, 2013). To help overcome these issues, the following measures, BDEFS (Barkley, 2011) and LASSI (Weinstein & Palmer, 2002), were adopted in the study. The researcher also developed a questionnaire to gather information about students' mobile device usage information and a weekly survey to get feedback on the mobile EF coaching solution on Qualtrics.

Instrumentation of BDEFS and LASSI. The BDEFS has been widely used in studies on ADHD coaching-related EF challenges (i.e., Prevatt & Yelland, 2015). Barkley (2011) and Barkley and Murphy (2010) used the behavioral ratings of impairment to describe a new EF schema. In this scale, Barkley (2011) categorized EF into five domains: Self-Organization/Problem Solving, Self-Management to Time, Self-Restraint or Inhibition, Self-Regulation of Emotion, and Self-Motivation. Allee-Smith, Winters, Drake, & Joslin (2013) reviewed BDEFS and identified it was well grounded in the literature on EF theoretically and empirically as a useful platform and instrument for evaluating the type and extent of EF deficits. The long form of the scale contains 89 items and takes an adult approximately 15 to 20 minutes to complete. The behavior challenges that underlie the BDEFS items are related to individuals with ADHD or prefrontal cortex damage.

The LASSI (Weinstein & Palmer, 2002) is a well-normed online survey. It contains 80 items that identify students' academic behavior and beliefs from a large sample of 1,092 college students. After reading a descriptive statement, students choose a response that reveals the extent to which that behavior or belief is typical. The scoring results are categorized in three areas: Skill, Self-Regulation, and Will (Weinstein & Palmer, 2002). For example, there are four scales that produce a Self-Regulation cluster score to measure changes in participants' EFs in this survey. These scales include: Concentration, Time Management, Self-Testing, and Study Aids. Now each scale in the third edition is comprised of six items instead of eight items. It takes approximately 9-11 minutes to complete the LASSI.

Pre- and post-measures. During Stage 1 preparation, participants completed (a) a questionnaire, (b) the BDEFS scale for adults ages 18-81, and (c) the LASSI scale.

The questionnaire. The researcher developed a questionnaire that gathered information about students' mobile device usage information. This questionnaire was piloted with a convenience sample of college students prior to use. The purpose of the pilot was to identify issues with the questionnaire's design. See Appendix B for a copy of the questionnaire.

Weekly Survey. In order to receive weekly feedback (W1, W2, W3, W4, W5, W6) from the mobile EF coaching solution, the researcher designed the survey on Qualtrics based on the feedback interview questions from Bellman, Burgstahler, and Hinke (2015). The weekly survey was developed after interviews with 4-5 people who worked with SWDs in post-secondary STEM education or who had learning experiences in post-secondary STEM education. The pilot study of the survey was conducted among 4-5 pre-service or in-service college students with and without disabilities at the School of Education. See Appendix C for copies of the weekly survey.

Field notes. This part documented field notes by a researcher. Field notes helped the researcher provide evidence to produce meaning and an understanding of the research context. The researcher wrote filed notes at a normally fixed time and place. The notes were taken as soon as possible after each session. A reflection journal documented the thoughts and ideas on the study plan, study methods, issues in data collection, etc.

Goal Attainment Scaling. GAS was used to collect data on student progress on academic goals. Each student worked up to one or two academic goals during the semester that were scored using GAS. GAS "involves establishing goals and specifying a range of outcomes or behaviors that would indicate progress toward achieving those goals" (Carr, 1979, p. 89). GAS scores were collected at the end of the study. See Appendix D for the GAS table.

Validity and Reliability

In the BDEFS test review, internal consistency measures used Cronbach's alpha ranging from .91 to .96 for all subscales and Pearson's product–moment correlation (r) across subscales with a range from .55 to .80 (Allee-Smith et al., 2013). In test–retest reliability, 62 randomly selected participants from the normative sample completed the self-report for a second time within two to three weeks. The comparison of scores on the follow-up test and the original scores, with correlations between each administration, was reported satisfactory ($r = .62$ to .80, $p < .001$, across all indices) (Allee-Smith et al., 2013). The correlation of subscales of the P-BDEFS to various EF tests was also reported on the exploration of construct and criterion validity, such as the Conners CPT and the Stroop Color–Word Test, ranged from .04 to .41 and –.01 to –.31(Allee-Smith et al., 2013). Allee-Smith and colleagues (2013) also reported that the direction of all correlations being theoretically correct. Please see Appendix A for BDEFS test review.

Coefficient Alphas for the LASSI scale ranged from .76 to .87 in a pilot test among 2,400 freshmen at a university in the United States (Weinstein, Palmer, & Acee, 2016). The scale kept high standards of psychometric quality in the field test/norming version. The field test was administered to 1,092 students, who were from 12 different institutions from different geographical regions and different types of organizations. The reported Cronbach's alpha reliability coefficient on the LASSI, 3rd Edition, was .76 or above (Weinstein et al., 2016). Please see Appendix A for LASSI overview.

Goal Attainment Scaling (GAS) was used to collect data on student progress on academic related goals in this study. The studies on Goal Attainment Scale Development and Measurement on interrater agreement explained that GAS ratings were reliable with clear and measurable objectives (Cytrynbaum et al. 1979; Schlosser 2004; Shefler, Canetti, & Wiseman, 2001). The impact of the SDLMI on student educational goal attainment has been examined with rich research-based evidence (Shogren et al., 2012; Lee, Wehmeyer, Palmer, Soukup, & Little, 2008; Wehmeyer et al., 2000). Recently, Shogren and colleagues (2012) used a group-randomized trial control group study to evaluate the impact of the SDLMI on academic and transition goal achievement and access to the general education curriculum. The study found that instruction using the SDLMI resulted in significant changes in goal attainment and access to the general education curriculum.

Data Collection Procedures

The researcher and participants met twice in one classroom at the School of Education to complete screening, soliciting, and training. The screening and training meeting took 40 minutes individually. The second part implemented coaching activities with the use of a design package. In this part, the researcher and participants met one-to-one to complete coaching activities through a mobile application for six weeks during Spring 2018. The mobile application WhatsApp was used in the experiment. The researcher and participants set up weekly goals together in Part 2 during each coaching session from Week 1 to Week 6, and the researcher provided mobile EF coaching activities to support the EF skills of individuals based on individualized learning needs through the use of WhatsApp. For detailed data collection procedures, please see Appendix H for a week-to-week breakdown of the coaching activities.

Summary of Data Collection Procedures

In Part 1: Training 1, the first face-to-face meeting took place in a classroom at the School of Education and was around 50 minutes. During the first meeting, participants were informed about the study and agreed or disagreed to participate through signing a consent form.

They completed a questionnaire about their usage of mobile devices and self-reported their challenges, strengths, resources, and perceived needs as well as their expectations for coaching. For the content of the questionnaire, please see Appendix B. The researcher administered a pre-test of the EF scale and LASSI scale. The two scales took 30-40 minutes to complete in total. Then, participants were informed individually about their EF scale scores after initial data-analysis. The researcher coded and analyzed the self-reported data of all participants with and without disabilities. The data were analyzed and used to understand the personalized learning needs of those participants.

In Part 1: Training 2, the second face-to-face meeting took place in a classroom at the School of Education and took around 50 minutes. The researcher discussed a coaching plan with participants and explained how to use WhatsApp. The researcher introduced the basic features and the functions that would be used in this study. The researcher addressed questions regarding the coaching process, what coaching would “look” like, measures of progress, confidentiality, time, WhatsApp features, etc. The researcher coached and modeled how to set up personalized academic goals and develop goal attainment scaling (GAS) (Carr, 1979; Shogren et al., 2012). The researcher introduced the layout of the study plan for Spring 2018 and set up the schedule for the first week. For structured protocols, please see Appendix H.

In Part 2: Coaching Activities Intervention Session, in Weeks 1, 2, 3, 4, 5, and 6, the same design package was used during each coaching session. The researcher and participants completed the coaching activities via the video/phone function of the WhatsApp application with additional check-ins via email/voice mail/text. The meeting schedule was based on each student/participant’s desired time to meet each week. Each coaching session started with goal setting and revisiting GAS (Shogren et al., 2012; Ruble et al., 2012). The researcher and the participant set up and revisited one or two academic goals for the Spring 2018 semester. These goals were used to guide all future coaching sessions. The goals were broken down into daily and weekly goals in the first 10 minutes of the coaching session. The participant led the process during the first 10 minutes of the session. Based on the participant's request, the researcher coached each participant on how to manage assignments or how to manage time during each coaching session. Participants also took a weekly survey to provide feedback on this mobile EF coaching solution. The researcher kept a research log and administered a post-test of the EF scale, LASSI scale, and GAS. The EF scale and LASSI scale took 30-40 minutes to complete in total. GAS took 3-5 minutes.

Data Analysis

The researcher used a mixed-methods approach in this study. This mixed methods study design aimed to explore broader perspectives in understanding what features of the mobile EF coaching solution were helpful to support SWDs and to explore and confirm how to provide EF coaching to support the learning process for students with different social backgrounds. A major identified advantage of the mixed methods research was used in this study, in which the researcher can both answer confirmatory and exploratory questions and therefore can confirm and create theory in the same study (Teddlie & Tashakkori, 2003).

The mixing happened during the data analysis phase of this study. Since there were only seven participants in this study, descriptive statistics were used to describe the basic features of the data in the study. Descriptive statistics can provide simple summaries about the sample and measures with a simple graphics analysis of quantitative data. A paired samples t-test (Kim, 2015) was used to analyze pre-test and post-test data to understand the effects of the use of a mobile coaching app on EF skills. The researcher used a SPSS paired samples t-test to test whether the mobile EF coaching solution significantly impacted EF skills and learning strategies with a comparison of the means of the pre-test results and the post-test results on the BDEFS-LF scale. However, this study had limited statistics power to make any prediction about the impact of this mobile coaching solution on EFs and learning strategies and skills due to small sample size. The Reliable Change Index (RCI) threshold number from the BDEFS-LF scale was used to ensure that the degree of change was reliable and exceeded what may result merely from measurement error or unreliability (Jacobson, Roberts, Berns, & Mczglinchey, 1999; Barkley, 2011). The researcher also calculated effect sizes using the package Effsize (Torchiano, 2017) in programming environment R (R Development Core Team, 2017).

Two coding cycles were used to compare and analyze the qualitative data. The qualitative data included a) one questionnaire, which collected data on the challenges of students in STEM gateway courses and how they use mobile devices in their academic learning; b) six weekly qualitative surveys with open-ended questions; and c) coaching activity data. The first cycle coding methods included the structural coding method and magnitude coding method (Saldaña, 2009). Saldaña (2009) stated that structural coding is suitable for interview transcripts and open-ended responses. This method is question-based coding that "act[s] as a labeling and indexing device, allowing researchers to quickly access data likely to be relevant to a particular analysis from a larger data set" (Namey et al., 2008, p. 141; Saldaña, 2009, p. 90). Structural coding can be used to examine comparable segments' commonalities, differences, and relationships through coding and initially categorizing the data corpus (Saldaña, 2009). During the first coding cycle, the magnitude coding method will also be used as a way of "quantitatizing" and/or "qualitiatizing" a phenomenon's intensity, frequency, direction, presence, or evaluative content (Tashakkori & Teddlie, 1998; Saldaña, 2009, p. 90). Namey et al. (2008) identified that a code frequency report can help identify which themes, ideas, or domains were common and which rarely occurred. They also suggested that determining frequencies is based on the number of individual participants who mention a particular theme, rather than counting the total number of times a theme shows in the text (Namey et al., 2008). In this study, the researcher completed a code frequency report about the identified improved learning skills with the use of the mobile coaching app based on the data from the six weekly surveys. Pattern coding (Saldaña, 2009) was used as a second cycle coding method to develop category labels, themes, and concepts through identifying similarly coded data and attributing meaning to that organization. Specifically, pattern coding put together and reorganized all the first level codes to develop a smaller and more select list of broader categories, themes, or concepts to help the researcher categorize and crystallize the analysis further (Saldaña, 2009). Pattern coding was helpful in condensing large amounts of data into a smaller number of analytic units and developing major themes from the 40 coaching sessions in this study. It was necessary to adopt the second cycle coding to explore and investigate the complex learning variables and the features of this mobile EF coaching solution in potentially providing support to the success and persistence of SWDs in post-secondary STEM education.

Chapter 4

Results

This study investigated the impact and the design of a mobile EF coaching solution among post-secondary students with and without disabilities who had EF challenges in the STEM gateway classes. The primary purpose of the study was to understand the design of a mobile EF coaching relationship focused toward the improvement of EF skills. Specifically, relevant EF challenges and educationally-adaptive skills included setting goals, planning, prioritizing, managing time, managing assignments, and staying on task (Barkley, 2011; Parker & Boutelle, 2009). The study included two sessions of face-to-face training and six sessions of individualized mobile coaching meetings for eight weeks in total. This chapter presents results to answer the four research questions: 1) What are the identified outcomes of participation in this mobile EF coaching support, 2) How did changes in EFs happen in this mobile EF coaching solution, 3) What are the perceived EF challenges for those participants in post-secondary STEM gateway classes, and 4) What differences do participants perceive between this mobile EF coaching solution and other types of support services in post-secondary STEM education? Therefore, this chapter primarily presents five parts of the results: 1) a summary of the pre-test and post-test results of the BDEFS-LF and LASSI scale to understand changes in EFs and to summarize the general outcomes of participation in this study; 2) a summary of themes in the six coaching activities to understand how changes in EFs happened in this mobile coaching solution; 3) within the general report of the BDEFS-LF and LASSI results, a detailed analysis of the changes in EFs, with a focus on goal-setting, time management, and assignment management, to understand the outcomes of participation in the study; 4) a summary of the perceived challenges in STEM classes; and 5) a comparison of the difference between this mobile EF coaching solution and other types of support services for students with and without disabilities in post-secondary STEM education. All participants' names are pseudonyms in this study.

Summary of the Pre-test and Post-test Results of BDEFS-LF and LASSI

The instruments of BDEFS-LF and LASSI were used in the pre/post-test to measure EF skills and learning strategies. Only seven participants completed this mobile coaching study. A descriptive statistics method was used to describe the basic features of the data in this study. Descriptive statistics provided simple summaries and a comparative analysis of pre/post test results for all participants to understand changes in their learning strategies and EF skills through participating in this study. In the following part, the researcher summarized and analyzed the pre-test and post-test results of BDEFS-LF and LASSI with simple charts for those seven participants.

The pre-test and post-test results of BDEFS-LF for all participants. This part describes the results of all seven participants in the mobile EF coaching study measured through the BDEFS-LF scale in pre/post-test. As mentioned in previous chapters, EFs primarily involve several types of self-directed and interactive activities, including setting goals and selecting, enacting, and sustaining actions across time toward those goals (Barkley, 2011). The BDEFS-LF measures an individual's EFs through the extent of completing these activities. The pre-test and post-test results of BDEFS-LF for the seven participants primarily include four parts: 1) total EF summary score, 2) ADHD-EF index score, 3) EF symptom counts in both pre-test and post-test, and 4) the results of the subscales in BDEFS-LF. Please see Table 4 for a comparison of pre/post testing sample results of those four parts on the BDEFS-LF scale.

The total EF summary score on the BDEFS-LF scale ranged from 89 to 356 for each participant. In this study, the mean difference of the total EF summary score was 30.14 for all seven participants. For any changes in the total EF summary score to be substantially meaningful on the BDEFS-LF scale, the Reliable Change Index (RCI) threshold number should be 44.35. The RCI threshold number is used to ensure that the degree of change is reliable and exceeds what may result merely from measurement error or unreliability (Jacobson, Roberts, Berns, & Mczglinchey, 1999; Barkley, 2011). Therefore, the total EF summary score change of 30.14 was not substantial compared to the RCI threshold number 44.35 in this study, but the EF mobile coaching seems to be a promising solution to provide EF support to individuals who are struggling with EF challenges in post-secondary STEM gateway classes.

The researcher used a SPSS paired samples t-test to test whether the mobile EF coaching solution significantly impacted EF skills and learning strategies with a comparison of the means of the pre-test results and the post-test results on the BDEFS-LF scale. In general, the study results had limited statistics power, as there were only seven participants in this study. The t-test investigated the impact of the mobile coaching solution on changes in EFs and learning strategies for each individual participant in this study. With limited statistics power to predict changes in EFs due to small sample size, the pre/post-testing sample results showed the changed skills in the following reported subscales were statistically significant with p. < 0.05. Therefore, the pre/post-testing sample results indicated this mobile EF coaching solution is promising in providing EF support to individuals with EF deficits and requires further research to provide statistical power through experimental studies.

Table 4

Comparison of Pre/Post Testing Sample Results on BDEFS Scores (n= 7)

	Pre-Test		Post-Test					
Score	Mean	SD	Mean	SD	Mean Diff.	RCI Threshold	t.	p. (2-tailed)

Total EF Summary Score	144.43	30.193	114.29	22.743	30.14	44.35	5.90	0.001
Total EF Symptom Counts	45.86	45.918	12.14	24.375	33.71	N/A	3.70	0.01
ADHD-EF Index	18.29	3.546	14.14	2.795	4.14	N/A	5.39	0.002
Self-Management to Time	38.43	8.791	28.57	10.406	9.86	13.49	5.91	0.001
Self-Organization/Problem Solving	39.29	9.429	29.57	4.353	9.71	10.78	3.60	0.011
Self-regulation of Emotions	22.57	6.803	18.29	6.102	4.29	10.40	2.68	0.037
Self-Restraint	27.14	4.981	23.29	2.984	3.86	12.78	2.54	0.044

Note: Mean diff., differences in the pre/post-test means; t, results for the paired-samples t-test; p, probability value for the t-test if ≤.05. The Reliable Change Index (RCI) threshold number is necessary for pre/posttreatment difference scores to be significant (reliable) on the BDEFS-LF subscales and the BDEFS-LF Total EF Summary Scores (Barkley, 2011). In this study, the RCI threshold number refers to the normative sample for the 18-34 age group.

Please see Table 5 for pre/post-test results on the Total EF Summary Score for each participant. Table 5 total EF summary score showed the five subscale total raw scores of all participants, including self-management to time, self-restraint, self-organization/problem solving, self-motivation, and self-regulation of emotions. All the EF summary scores of the seven participants decreased to different extents in the comparison of pre/post-test results. Lillian, a participant who self-identified as having severe migraines, achieved a raw score change of 51 in the pre/post-test results on the total EF Summary Score. Table 5 shows that Lillian’s raw score change of 51 is with significance, well above the RCI threshold of 44.35. Her Total EF Summary Score also improved from the category of indicating an EF deficit with a 95 pre-test percentile to the normal range of 51-75 post-test percentile. Zoey’s raw change score of 45 was also above the RCI threshold of 44.35. Her Total EF Summary Score improved from the category of the normal range of 51-75 pre-test percentile to the category of the normal range of 1-25 post-test percentile. Therefore, both Lillian and Zoey’s Total EF Summary Score change was of a significant magnitude at or exceeding the RCI (threshold) that would be expected less than 5% of the time by chance and unreliability of measurement alone. Indeed, the improvement was likely a consequence of the mobile EF coaching solution. However, the reliable change referred here only to a temporary effect of the mobile EF coaching solution.

Table 5

Comparison of Pre/Post Testing Sample Results on BDEFS Scores (n= 7)

Participant	Pre-test Percentile Range	Post-test Percentile Range	Pre-test Raw Score	Post-test Raw Score	Raw Score Change	RCI
Zoey	51-75%	1-25%	143	98	45	44.35
Jean	26-50%	1-25%	130	97	33	
Lillian	95%	51-75%	209	158	51	
Ava	26-50%	1-25%	129	105	24	
Joe	26-50%	1-25%	116	95	21	
Mia	51-75%	26-50%	146	123	23	
Emma	51-75%	26-50%	138	124	14	

Note. The percentiles that range from 1-25, 26-50, and 51-75 reflect the normal range of deficits on the BDEFS-LF scale. The more deviant the score is relative to the general population, the higher the percentile (Barkley, 2011). In this study, the RCI threshold number refers to the normative sample for the 18-34 age group.

Next, the pre/post test results of the EF symptom counts from the BDEFS-LF self-report indicated that the probability of EF deficit for all participants decreased. EF symptom counts refer to counting the number of items with responses that were answered with a three (often) or a four (very often), and the number can be used to indicate the likelihood of clinical symptoms of an EF deficit (Barkley, 2011). In the normative sample, there was no significant sex difference in EF symptom counts nor did significant interaction of age with sex exist, while a significant effect of age groups existed (Barkley, 2011). In addition, the specific breakdown scores were provided only above the 75th percentile (Barkley, 2011). In general, all seven participants at the age group of 18 to 30 reduced the chance of having an EF deficit to a large extent through participating in this study. Lillian reduced her EF symptom counts percentile from the 99th to the 51-75th percentile in a pre/post-test results comparison. Three other participants also reduced their EF symptom counts percentile to the normal range of deficits on the BDEFS-LF scale. Please see Table 6 for pre/post-test results of each individual's EF symptom counts.

Table 6

Pre/post Test Results on Total EF Symptom Counts

Participant	Pre-test Percentile	Post-test Percentile	Pre-test Raw Score	Post-test Raw Score
Zoey	97	≤ 50	51	0
Jean	88	≤50	28	0
Ava	51-75	≤50	12	0
Joe	51-75	≤50	6	0
Lillian	99	51-75	141	66
Emma	87	≤50	26	4
Mia	97	76	57	15

Note. A symptom is any item on the BDEFG answered with a 3 (often) or a 4 (very often). The normal range of deficits on the BDEFS-LF scale includes the percentiles that are ≤50 or range between 51-75 (Barkley, 2011).

Another summary score from the BDEFS-LF scale is the ADHD-EF index score. Please see Table 7 for each individual's ADHD-EF index score. An ADHD-EF index score can be used to indicate the likelihood that the participant may have ADHD (Barkley, 2011). Barkley (2011) stated if the ADHD-EF index is scored at 20 or higher, it indicates the adult may have ADHD. The ADHD-EF scale was reported to successfully identify 94% of adults with ADHD in the normative sample, missing just 6% of that group (Barkley, 2011). In this study, two participants indicated having ADHD through their ADHD-EF index raw score, 25 and 20 in pre-test results. Jean, who took daily medication to control anxiety, reduced her ADHD-EF index raw score from the 51-75th percentile to the 26-50th percentile. Lillian, with severe migraines, reduced her ADHD-EF index raw score from the 92nd percentile to the 51-75th percentile in a normal range of deficits on the BDEFS-LF scale after participating in this study.

Table 7

Pre/post Test Results on ADHD-EF Index

Participant	Pre-test Percentile	Post-test Percentile	Pre-test Raw Score	Post-test Raw Score
Zoey	51-75	1-25	19	12
Jean	51-75	26-50	20	15
Ava	26-50	1-25	16	12
Joe	26-50	1-25	14	11
Mia	26-50	26-50	17	14
Emma	26-50	26-50	17	16
Lillian	92	51-75	25	19

Note. The normal range of deficits on the BDEFS-LF scale, including the percentiles that range from 1-25, 26-50, and 51-75. The more deviant the score is relative to the general population, the higher the percentile (Barkley, 2011).

The results of the subscales in BDEFS-LF. In general, the results of the total raw scores of the subscales of all participants showed different extents in change in EF skills in pre/post-test. Table 8 presents pre/post-test results on specific subscale raw scores, including self-management to time, self-restraint, self-organization/problem solving, and self-regulation of emotions. Table 8 presents the RCI threshold number to understand whether the raw score change in pre/post test results is significant (reliable) or not on the BDEFS-LF subscales and the total EF summary scores. Table 8 shows that three participants significantly improved their self-organization/problem solving skill. On the self-organization/problem solving subscale, Lillian's raw change score was 20, Mia's raw change score was 16, and Zoey's raw score change was 13. They are all above the RCI threshold 10.78, and the improvement in self-organization/problem solving is likely a consequence of the mobile EF coaching solution. In addition, Zoey improved her time management skill significantly with a raw score change of 19, compared to the RCI threshold 13.49 on the self-management to time subscale. Lillian improved her self-regulation of emotions skill significantly with a raw score change of 11, compared to the RCI threshold 10.40 on the self-regulation of emotions subscale.

Table 8

Pre/post Test Raw Score on the Four Subscales in BDEFS-LF

	Self-Management to Time			Self-Restraint			Self-Organization/Problem Solving			Self-Regulation of Emotions		
Participant	Pre-test raw score	Post-test raw score	Raw score change	Pre-test raw score	Post-test raw score	Raw score change	Pre-test raw score	Post-test raw score	Raw score change	Pre-test raw score	Post-test raw score	Raw score change
Mia	36	25	11	26	25	1	47	31	16	24	27	-3
Emma	35	27	8	28	27	1	34	34	0	22	20	2
Ava	33	25	8	22	22	0	34	29	5	21	15	6
Zoey	42	23	19	24	21	3	40	27	13	18	13	5
Lillian	57	52	5	37	27	10	56	36	20	37	26	11
Jean	33	24	9	29	20	9	36	26	10	19	14	5
Joe	33	24	9	24	21	3	28	24	4	17	13	4

The results of the pre/post-test percentile on the above mentioned four subscales is presented in Table 9. Mia, the participant with an anxiety disorder, improved her self-organization/problem-solving skill from the 82nd pre-test percentile to the normal range of deficits on the BDEFS-LF scale. Lillian, with severe migraines, improved her time management skill from the 96th percentile to the 85th percentile, self-restraint skill from the 80th percentile to the normal range, self-organization/problem solving skill from the 94th percentile to the normal range, and self-regulation of emotions from the 96th to the 84th percentile on the BDEFS-LF scale.

Table 9

Pre/post Test Percentile on the Four Subscales in BDEFS-LF

	Self-Management to Time		Self-Restraint		Self-Organization/Problem Solving		Self-regulation of Emotions	
Participants	Pre-test Percentile	Post-test Percentile	Pre-test Percentile	Post-test Percentile	Pre-test Percentile	Post-test Percentile	Pre-test Percentile	Post-test Percentile
Mia	51-75	1-25	26-50	26-50	82	26-50	51-75	76
Emma	26-50	1-25	51-75	51-75	26-50	26-50	51-75	51-75
Ava	26-50	1-25	1-25	1-25	26-50	26-50	51-75	26-50
Zoey	51-75	1-25	26-50	1-25	51-75	26-50	26-50	1-25
Lillian	96	85	80	26-50	94	51-75	96	84
Jean	26-50	1-25	51-75	1-25	51-75	1-25	26-50	1-25
Joe	26-50	1-25	26-50	1-25	26-50	1-25	51-75	1-25

Note. The normal range of deficits on the BDEFS-LF scale included the percentiles that range from 1-25, 26-50, and 51-75. The more deviant the score is relative to the general population, the higher the percentile (Barkley, 2011).

The pre-test and post-test results of LASSI for all participants. This report provides pre/post-test LASSI scores as well as the percentage of change in raw scores for participants before and after receiving coaching. Ten scales were included in the LASSI scale, including Time Management (TMT), Self-Testing (SFT), Anxiety Scale (ANX), Attitude Scale (ATT), Concentration Scale (CON), Information Processing Scale (INP), Motivation Scale (MOT), Selecting Main Ideas Scale (SMI), and Self Testing Scale (SFT). Based on the LASSI scale (Weinstein & Palmer, 2002), if the score is above the 75^{th} percentile on any of the ten LASSI scales, one does not have to give a high priority to improving the strategies in those areas, 75-100; the researcher coded it as 3. If the score is between the 75^{th} and the 50^{th} percentiles on any of the ten scales, one should consider improving the strategies for those scales, 50-75; the researcher coded it as 2. If the score is below the 50^{th} percentile on any of the ten scales, one needs to improve the skills to avoid serious problems succeeding in college, 0-50; the researcher coded it as 1. See Table 10 for changes in the mean percentiles in pre/post-test results on the LASSI scale. All ten learning strategies and skills were improved to a higher level of code category in pre/post-test mean percentile comparison.

Table 10

The Change of the Mean Percentile in Pre/Post-test Results on LASSI Scale (n=7)

	Mean Pre-test Percentile	Coded Category	Mean Post-test Percentile	Coded Category
TMT	45	1	81	3
UAR	52	2	82	3
SFT	41	1	87	3
SMI	51	2	86	3
CON	46	1	74	2
TST	53	2	89	3
ANX	48	1	74	2

ATT	59	2	80	3
MOT	46	1	70	2
INP	57	2	92	3

Note. If the score is above the 75th percentile on any of the ten LASSI scales, one does not have to give a high priority to improving the strategies in those areas, percentile score 75-100. If the score is between the 75th and the 50th percentiles on any of the ten scales, one should consider improving the strategies for those scales, 50-75, If the score is below the 50th percentile on any of the ten scales, one needs to improve skills to avoid serious problems succeeding in college, 0-50 (Weinstein & Palmer, 2002).

In this study, most participants showed improved skills on TMT, SFT, INP, and CON when comparing pre/post-test raw scores. The following part presents the comparison of pre/post testing sample results of all subscales on LASSI scores, the information of the improved skills for most participants, and the comparison of pre/post testing sample results of all subscales for three participants with disabilities or health conditions. The understanding of the impact of this mobile coaching solution on EFs changes among students with disabilities contributes to the literature of empirical studies to provide support to students with special needs in post-secondary STEM gateway classes. Please see Table 11 for understanding the comparison of pre/post testing sample results of all subscales on LASSI scores (n= 7). For all seven participants, most skills were improved with statistical significance in comparison of pre/post testing sample results on the LASSI scale.

Table 11

Comparison of Pre/Post Testing Sample Results on LASSI Scores (n= 7)

	Pre-Test		Post-Test					
Score	Mean	SD	Mean	SD	Mean Diff.	t.	Effect size	p. (2-tailed)
TMT	17.57	5.473	24.43	5.062	6.857	6.231	2.20	0.001
UAR	21.14	3.716	27	3.873	5.857	3.78	1.34	0.009
SFT	17.43	4.962	25.29	2.928	7.857	5.885	2.08	0.001
SMI	20.86	6.122	26.86	2.41	6	3.133	1.11	0.02
CON	19	4.583	24	4.509	5	2.983	1.06	0.025

TST	21.43	5.028	27	1.826	5.571	3.994	1.41	0.007
ANX	18.43	7.871	23.29	6.157	4.857	2.109	0.75	0.08
ATT	25.43	2.299	27.86	1.952	2.429	2.437	0.86	NS
MOT	23.71	2.812	26.57	3.207	2.857	2.374	0.84	NS
INP	23.14	4.525	28.71	2.215	5.571	3.3	1.17	0.016

Note. SD., standard deviation; Mean diff., differences in the pre/post-test means; t, results for the paired-samples t-test; p, probability value for the t-test if ≤.05; NS, not significant. On effect size, d=0.2 represents a 'small' effect size, 0.5 a 'medium' effect size, and 0.8 a 'large' effect size (Cohen, 1988). Effect sizes were calculated using the package Effsize (Torchiano, 2017) in programming environment R (R Development Core Team, 2017).

On the LASSI scale, the TMT score indicates that an individual is managing time well to complete academic tasks while planning time for social contacts (Weinstein & Palmer, 2002). It emphasizes that one does not procrastinate, and one can balance other responsibilities and study load well. In this study, the TMT scores showed that every participant improved their time management skill after receiving the mobile EF coaching. The percent change raw score ranged from 8% to 73%. Four participants improved their time management skill by almost 50%, and one participant improved by 73%. Please see Table 12 for a comparison of pre/post test scores on the time management skill of the seven participants.

Table 12

Comparison of Pre/Post Test Scores on Time management Scale

Participant	Pre-Test Percentile Score	Post-Test Percentile Score	Pre-Test Raw Score	Pre-Test Raw Score	% Change Raw Score
Mia	40	90	17	26	53%
Emma	40	90	17	25	47%
Ava	25	90	15	26	73%
Zoey	35	80	16	23	44%
Lillian	1	20	9	14	56%
Jean	90	95	25	27	8%
Joe	85	99	24	30	25%

Note. If the score is above the 75th percentile on any of the ten LASSI scales, one does not have to give high priority to improving the strategies in those areas, percentile score 75-100. If the score is between the 75th and the 50th percentiles on any of the ten scales, one should consider improving the strategies for those scales, 50-75. If the score is below the 50th percentile on any of the ten scales, one needs to improve skills to avoid serious problems succeeding in college, 0-50 (Weinstein & Palmer, 2002).

In LASSI, the SFT score indicates that once a learner has begun to use this strategy as an essential part of learning and can consistently review and monitor what has been learned/not learned, then that learner can discover and identify which material still needs to be restudied (Weinstein & Palmer, 2002). All seven participants demonstrated improved self-testing skill after receiving coaching support. One participant showed strong self-testing skill before the study, and the other six participants showed improvement in the self-testing skill, ranging from 7% to 87%, through participation in this study. Please see Table 13 for a comparison of Pre/Post Test Scores on Self Testing Scale.

Table 13

Comparison of Pre/Post Test Scores on Self Testing Scale

Participant	Pre-Test Percentile Score	Post-Test Percentile Score	Pre-Test Raw Score	Pre-Test Raw Score	% Change Raw Score
Mia	25	95	15	28	87%
Emma	50	90	1wsx8	26	44%
Ava	25	90	15	25	67%
Zoey	95	99	28	30	7%
Lillian	50	80	18	23	28%
Jean	20	75	14	22	57%
Joe	20	80	14	23	64%

Note. If the score is above the 75th percentile on any of the ten LASSI scales, one does not have to give high priority to improving strategies in those areas, percentile score 75-100. If the score is between the 75th and 50th percentiles on any of the ten scales, one should consider improving the strategies for those scales, 50-75. If the score is below the 50th percentile on any of the ten scales, one needs to improve skills to avoid serious problems succeeding in college, 0-50 (Weinstein & Palmer, 2002).

The INP score in the LASSI scale implies that someone can apply what they already know to what one is trying to learn, which supports both obtaining and memorizing new information (Weinstein & Palmer, 2002). The skills that build the connection between prior knowledge and new knowledge are helpful (Liu, Grady, & Moscovitch, 2016). Three participants improved their information processing skill through participation in this study, with a percent change raw score ranging from 43% to 58%. Another three participants had strong information processing skill in pre-test. Two showed improvement and one almost remained at the same skill level in the study. Please see Table 14 for a comparison of pre/post test scores on the information processing scale.

Table 14

Comparison of Pre/Post Test Scores on Information Processing Scale

Participant	Pre-Test Percentile Score	Post-Test Percentile Score	Pre-Test Raw Score	Pre-Test Raw Score	% Change Raw Score
Mia	25	99	19	30	58%
Emma	45	65	21	24	14%
Ava	20	90	18	28	56%
Zoey	80	99	26	30	15%
Lillian	99	95	30	29	-3%
Jean	85	99	27	30	11%
Joe	45	99	21	30	43%

Note. If the score is above the 75th percentile on any of the ten LASSI scales, one does not have to give high priority to improving strategies in those areas, percentile score 75-100. If the score is between the 75th and 50th percentiles on any of the ten scales, one should consider improving the strategies for those scales, 50-75. If the score is below the 50th percentile on any of the ten scales, one needs to improve skills to avoid serious problems succeeding in college, 0-50 (Weinstein & Palmer, 2002).

The CON score on the LASSI scale specifically demonstrates whether it is challenging to maintain attention to academic tasks (Weinstein & Palmer, 2002). Even though there are momentary pauses on concentration, one can be aware of the situation and quickly return to academic tasks without serious interruption (Weinstein & Palmer, 2002). Altogether six participants improved their information processing skill through participation in this study, with a percent change raw score ranging from 4% to 92%, one participant remained at the same skill level indicated by the post-test score. Please see Table 15 for a comparison of pre/post test scores on the concentration scale.

Table 15

Comparison of Pre/Post Test Scores on Concentration Scale

Participant	Pre-Test Percentile Score	Post-Test Percentile Score	Pre-Test Raw Score	Pre-Test Raw Score	% Change Raw Score
Mia	10	85	13	25	92%
Emma	50	50	20	20	0 %
Ava	45	95	19	28	47%
Zoey	50	90	20	27	35%
Lillian	10	25	13	16	23%
Jean	85	95	25	28	12%
Joe	75	80	21	30	4 %

Note. If the score is above the 75th percentile on any of the ten LASSI scales, one does not have to give high priority to improving strategies in those areas, percentile score 75-100. If the score is between the 75th and 50th percentiles on any of the ten scales, one should consider improving the strategies for those scales, 50-75. If the score is below the 50th percentile on any of the ten scales, one needs to improve skills to avoid serious problems succeeding in college, 0-50 (Weinstein & Palmer, 2002).

The pre-test and post-test results of LASSI for participants with disabilities. For the pre/post test scores for three participants with disabilities or medical conditions in LASSI, please see Table 16 for Lillian, Table 17 for Zoey, and Table 18 for Jean. All three participants showed improved skills in the LASSI pre/post-test results. The pre/post-test raw scores of Lillian, the individual with severe migraines, showed improved skills on TMT, UAR, SFT, SMI, and CON with a 56%, 32%, 28%, 26%, and 23% change in raw scores.

Table 16

Pre/Post Test Scores in LASSI Scale for Lillian

Scale	Pre-Test Percentile	Post-Test Percentile	Pre-Test Raw Score	Pre-Test Raw Score	% Change Raw Score
TMT	1	20	9	14	56%
UAR	35	80	19	25	32%
SFT	50	80	18	23	28%
SMI	60	95	23	29	26%
CON	10	25	13	16	23%
TST	85	95	26	28	8%
ANX	99	99	30	30	0%
ATT	55	55	25	25	0%
MOT	50	50	24	24	0%

INP	99	95	30	29	-3%

Note. Time Management (TMT), Using Academic Resources Scale (UAR), Self-Testing (SFT), Selecting Main Ideas Scale (SMI), Concentration Scale (CON), Testing Strategies Scale (TST), Anxiety Scale (ANX), Attitude Scale (ATT), Motivation Scale (MOT), Information Processing Scale (INP) (Weinstein & Palmer, 2002).

For participant Zoey, the pre/post-test raw scores showed improved skills on ANX, TMT, MOT, CON, ATT, TST, and UAR with a 79%, 44%, 38%, 36%, 25%, 25%, and 25% change in raw scores. The anxiety management skill greatly improved in her pre/post test scores on the LASSI scale.

Table 17

Pre/Post Test Scores on LASSI Scale for Zoey

Scale	Pre-Test Percentile	Post-Test Percentile	Pre-Test Raw Score	Post-Test Raw Score	% Change Raw Score
TMT	35	80	16	23	44%
UAR	75	99	24	30	25%
SFT	95	99	28	30	7%
SMI	70	85	24	26	8%
CON	50	90	20	27	35%
TST	75	99	24	30	25%
ANX	25	85	14	25	79%
ATT	45	99	24	30	25%
MOT	20	90	21	29	38%
INP	80	99	26	30	15%

Note. See Table 16.

At the beginning of training sessions, participant Jean self-identified that she is taking medications to control her anxiety on a daily basis. She did not self-identify her medical situation to the disability office on campus. Therefore, she does not receive any accommodations for her academic access. The results of her pre/post test scores in LASSI showed great improvement in anxiety management.

Table 18

Pre/Post Test Scores on LASSI Scale for Jean

Scale	Pre-Test Percentile	Post-Test Percentile	Pre-Test Raw Score	Pre-Test Raw Score	% Change Raw Score

TMT	90	95	25	27	8%
UAR	35	35	19	19	0%
SFT	20	75	14	22	57%
SMI	40	60	20	23	15%
CON	85	95	25	28	12%
TST	10	80	16	25	56%
ANX	10	70	10	22	120%
ATT	75	65	27	26	-4%
MOT	30	20	22	21	-5%
INP	85	99	27	30	11%

Note: See Table 16.

Summary of Themes in the Six Coaching Activities

Structural coding was used in the first cycle coding to examine comparable segments' commonalities, differences, and relationships through coding and initially categorizing the data corpus (Saldaña, 2009). A code frequency report was used to identify which themes, ideas, or domains were common and which rarely occurred (Namey, Guest, Thairu, & Johnson, 2008). The results from the qualitative content analysis revealed the challenges of individuals with and without disabilities in their STEM gateway classes, available learning resources and tools, and changes in their EFs through participating in this study. In total, the researcher coded 40 transcripts of all coaching sessions, with a total of 735 excerpts. An assistant reviewed 10% of the coding work to ensure fidelity; no irregularities were found. Based on an analysis of 40 transcripts of coaching sessions, data were sorted and examined for five areas, including the three EF skills, monitoring progress, and feedback about coaching. This phase resulted in the identification of 39 descriptors characterizing challenges identification, obtainable academic goals, coaching time management skill, coaching assignment/tasks management skill, and then monitoring progress among and across the three skills. Pattern coding (Saldaña, 2009) was used as a second cycle coding method to analyze the data, and it revealed four overarching themes across the coaching sessions to understand the helpful features of this mobile EF coaching solution in supporting EFs: (a) identification of challenges, (b) setting obtainable and clear goals,

(c) providing support service to meet personalized needs, and (d) evaluating progress and providing timely feedback. In every coaching session, the researcher and each participant set and revisited obtainable and clear goals for that semester, resulting in 110 excerpts. The identification of challenges in approaching academic goals occurred among 70 excerpts. Among 413 excerpts, participants were provided with learning resources and tools (i.e., learning strategies and skills) to problem solve their challenges in post-secondary STEM classes and to meet their personalized learning needs in the learning process. In another 142 excepts, the researcher and the participants evaluated the learning progress. Timely feedback was provided in each coaching session. The UDL framework and the design of a UDL implementation blueprint provided a clear guideline for understanding the themes and the features of this mobile EF coaching solution in supporting EFs.

Summary on EFs Changes with a Focus on Goal-setting, Time Management, and Assignment Management

The changes in EFs focused on examining whether the mobile EF coaching support impacted those skills in the design-based coaching package, including goal-setting skill, time management skill, and assignments/tasks management skill. Goals outcomes were individually determined and measured to monitor the progress toward goal achievement (Shogren et al., 2012). Both quantitative and qualitative content analysis showed improved goal setting skill, time management skill, and assignment/tasks management skill.

Goal-setting skill. GAS was used to collect data on student progress on their academic goals. Each student worked on up to two academic-related goals during Spring 2018 that were scored using GAS. GAS helped to establish specific, objective, and obtainable goals with measurable outcomes or behaviors that would indicate progress toward achieving those goals

(Carr, 1979; Shogren et al., 2012). Each participant's goals outcomes were individually determined, including catching up on missed content in class, getting at least a better grade of B in the STEM gateway class, identifying and summarizing main ideas, being aware of and making use of available school resources, previewing STEM gateway class content, reviewing STEM gateway class content, preparing for tests, and understanding concepts in this study. After GAS ratings were made, GAS scores were converted to standardized T-scores (Kiresuk, Smith, & Cardillo, 1994). Standard scores of 50 represent acceptable outcomes, and standard scores of less than 40 indicate outcomes the researcher found less favorable than expected. The mean GAS score after mobile EF coaching was 51.4 (SD = 6.9), ranging from 40 to 60. In general, every participant reached the expected academic goals. Please see Table 19 for participants' GAS scores.

Table 19

Participants' GAS Scores

Level of Expected Outcomes	Rating	Mia	Ava	Emma	Zoey	Lillian	Jean	Joe
Much more than expected	+2 (70)							
More than expected	+1 (60)		60				60	
Expected outcome	0 (50)	50		50		50		50
Less than expected	-1 (40)				40			
Much less than expected	-2 (30)							

Time management skill. The results from pre/post-test on self-management to time showed that participants improved their time management skills on average by a 9.86 raw score (27%) in BDEFS-LF and a 6.86 raw score (39%) in LASSI. Please see Table 20 for pre/post-test raw score on self-management to time in BDEFS-LF. Results from post-test in BDEFS-LF showed that six participants improved their time management skill to the lowest percentile within the normal range of deficits in BDEFS-LF scale. Only the result of one participant, Lillian, still showed self-management skill difficulty in the post-test, but her post-test results also showed improved time management skill by a 5 raw score (9%) compared to her pre-test score on self-management to time.

Table 20

Pre/post Test Raw Score on Self-Management to Time in BDEFS-LF

Participant	Pre-test Percentile	Post-test Percentile	Pre-test raw score	Post-test raw score	% change raw score
Zoey	51-75%	1-25%	42	23	45%
Mia	51-75%	1-25%	36	25	31%
Ava	26-50%	1-25%	33	25	24%
Emma	26-50%	1-25%	35	27	23%
Jean	26-50%	1-25%	33	24	21%
Joe	26-50%	1-25%	33	24	21%
Lillian	96%	85%	57	52	9%

Note. The normal range of deficits in the BDEFS-LF scale, including the percentiles that range from 1-25, 26-50, and 51-75. The more deviant the score is relative to the general population, the higher the percentile (Barkley, 2011).

From the qualitative content analysis on time management skill coaching, seven unique aspects were identified from 243 coded excerpts within 36 transcripts of all coaching sessions. The majority of these descriptors fell into categories including building a digital calendar, arranging a reasonable amount of work every day, prioritizing activities, staying focused, keeping appointments, setting reminders, and sharing examples. The overarching theme within time management skill coaching included challenges identification, clear and obtainable goals, tools and resources, evaluation, and timely feedback.

At the beginning of the time management skill coaching session, three participants mentioned putting too many things on a daily to-do list. For example, participants identified that, by the end of the day, they ran out of time and could not complete all written tasks in one day. One participant mentioned about how she would stay up late to complete the to-do list of that day, reducing her sleep at night. Eventually, after doing that for three days, she felt exhausted and desperately needed sleep. She had to cancel some scheduled activities on Friday, as she was too tired. As coaching sessions moved forward, participants gradually began reflecting on their ability to self-identify what they were not doing well in the past and what they are doing now. They also developed skills in using a digital calendar to organize learning, to set reminders, and to stay focused on academic goals. The participants were able to evaluate their learning progress and make necessary adjustments in their original academic goals. For instance, during coaching session five, one participant commented, “so first you need to understand yourself. what you can do, what can you not do. What's your limit and then you can make the plan. So, we cannot pay attention to too many things, we cannot, you know, require ourselves to finish so many tasks just in one day.”

Assignment/tasks management skill. From the qualitative content analysis on assignment/tasks management skill coaching, six unique aspects were identified from 170 coded excerpts within 33 transcripts of all coaching sessions. The majority of these descriptors fell into categories including breaking down the assignment, planning the process, prioritizing tasks, using a digital calendar, getting reminders, and sharing examples. The overarching theme within assignment/tasks management skill coaching included challenges identification, clear and obtainable goals, tools and resources, evaluation, and timely feedback. Participants showed their mastery of the procedures and major concepts of managing assignment/tasks in academic settings. For instance, Ava mentioned that she now prioritizes her academic assignments instead of approaching them at the last minute.

The perceived outcomes of participation in a mobile EF coaching solution. Based on the data analysis from the six weekly surveys, participants identified the strategies or skills that they learned as a result of participating in the EF coaching via mobile application sessions. The researcher conducted a frequency counts report of the identified learning strategies or skills through analyzing question 8 from the six weekly surveys. See Table 21.

Table 21

A frequency counts report of the identified learning strategies or skills

Identified strategies or skills	Count of participants in six surveys	%
Time management and organization skills	20	80%
Goal setting	12	48%
Assignments management and organization skills	12	24%
Breaking projects into smaller steps or making outlines	10	20%
Study skills	6	48%
Stress management	5	40%
Being focused/staying on tasks	5	20%
Self-awareness	3	12%

Note. Each participant can make multiple choices from learning strategies or skills that they learned as a result of participating in this mobile EF coaching in each weekly survey.

From the qualitative content analysis of feedback on the mobile EF coaching support, eight unique aspects on positive outcomes were identified from 80 coded excerpts within 17 transcripts of all the coaching sessions. The majority of these descriptors fell into categories including having self-awareness of strengths and weaknesses, refraining from procrastination, being actively engaged, releasing anxiety, identifying and using resources, keeping appointments, developing organization/problem-solving, and self-testing. The most positive outcomes were in the first two categories: self-awareness of strengths and weaknesses and stopping procrastination. One participant was aware of her hesitance to ask questions, saying, “For me that's something I struggled with in the past because I was always the person that didn't want to ask questions because I didn't want to look stupid.” On the procrastination challenge, one participant stated, “Now I always do my homework first before anything else. I try and get my homework done first before I do anything that's not school related.” Another participant identified the learning strategy that stopped procrastination, “I like the concept of them saying handling the hardest task first. I'm guilty of procrastinating because I dread certain things. Now I try to tackle things I'm dreading the most.” In general, participants showed their improved learnings strategies on stopping procrastination in task/assignment management skill and on reflecting about what they were doing well and what they needed to improve in the self-testing skill.

After analyzing the six weekly surveys, the results showed all seven participants self-identified the influence of mobile phones on their academic learning. In this study, academic learning is defined as any time someone can use a mobile device to support information associated with the understanding or activities related to the classes. Regarding the question of “how you often use your phone to support your own academic learning?”, six participants reported that they used their phone in academic learning at least three to five times a day, and one said he used the phone in academic learning one to three times a day.

Current Challenges in STEM Gateway Classes

From the six weekly surveys analysis, 70 excerpts were coded from 18 transcripts of all coaching sessions regarding current challenges in the STEM gateway class. The challenges primarily included making a balance between work and life, refraining from procrastination, problematic instructional practices, missing classes, sticking to a plan, working memory, staying focused, etc. For instance, one participant mentioned her challenge in balancing work and life, saying, “like finishing homework readings, balancing work and school and social life is a challenge to me." The procrastination challenge was mentioned by three participants. "Mmmmm, when I first started it was probably really good but after a while I was probably just going through the motions when I did my assignment at [the] last minute," as one participant said about her procrastination challenges. Two participants mentioned challenges in understanding concepts due to problematic instructional practices. "It is boring, and it is difficult to stay focused in class." "The instructor speaks so fast. He gets caught up in his own words so it's hard to learn what he's really trying to teach." "Some professors might like, have a class set up to where they will stand up for 5 minutes and 'teach' the class and expect them to go home and do some extremely complex problems." "I had missed a lot of classes, due to like headaches stuff and nauseate." "It is difficult for me to stick to the plan: Sometimes I complete the plan well, sometimes I may just sleep over the time and could not compete it."

Other challenges identified in the current STEM class in the questionnaire were analyzed separately, as the data were collected in the first training session, before participants received the coaching activities in this study. The identified challenges were related to EFs, including procrastination, concentration, working memory, stress management, instructional practice, and sticking to the plan and implementation. Regarding procrastination, one participant mentioned that she always submitted assignments at the last minute. One participant identified her challenge on concentration, saying, "my phone [is] a distractor in my math class, and it is challenging to learn things very fast." Several participants experienced challenges from working memory, including having a hard time remembering all the formulas used for math, having a difficult time retaining information quickly, not following lecture-based learning very well, and taking longer to understand new concepts due to chronic migraines. Several participants expressed challenges sticking to the plan and implementation. They all mentioned that they planned their academic work daily and weekly, but four also expressed that it was challenging to stay on track to follow up with their plans in completing academic work. One participant, who was a non-traditional student, experienced challenges with how to manage stress. In her own words, she was having extreme test anxiety. Another participant identified challenges with instructional practice, saying that some instructors could not deliver knowledge in a clear and organized manner.

The Participants' Perceptions of the Mobile EF Coaching Solution and Other Types of Support Services in Post-Secondary STEM Education

Based on the data analysis from the six weekly surveys, participants provided comments in response to Q11 and Q12, which were open-response questions on their opinions of any differences between the mobile EF coaching support and other types of support services in post-secondary STEM education. Through analyzing Q11 in the six weekly surveys, the researcher conducted a frequency counts report of support services in post-secondary STEM education other than the mobile EF coaching support. Tutorial services (48%) and career advising (39%) were two most often used support services among all participants. Please see Table 22 for the frequency counts report.

Table 22

Any other types of support services in post-secondary STEM education besides the mobile EF coaching support identified by participants

Other types of support services	Number of participants	%
Tutorial services	11	48%
Career advising	9	39%
Academic coach	5	22%
Peer mentoring to facilitate team learning	4	17%
Academic skills centers	3	13%
Writing centers	1	4%

In the questionnaire, participants identified the resources and support services that they can use to help their learning in STEM classes. Those resources included study buddies, peer notes, YouTube, Google, textbooks, office hours for both instructors and graduate teaching assistants, Math Help room, Khan Academy, Purple Math, tutoring, confidence, more sleep, peer guidance, and the internet. Participants also clearly expressed their expectations for this coaching to help their learning in the STEM class. For instance, the following quotes were from the questionnaire: “I think it helps to stop procrastination”; “It provides help on how to balance my time with sports and work”; “It provides ways for me to remember everything that is important when taking the test”; “I am hoping to learn to adapt to fast-paced learning skills”; and “I hope it provides peer led coaching/tutoring.”

Identified differences existed between the mobile EF coaching support and other types of support services. The researcher conducted a frequency counts report through analyzing Q12 from the six weekly surveys. Please see Table 23 for the information that participants identified about how the mobile EF coaching support met individualized learning needs. Please see Table 23 for the frequency counts report.

Table 23

A code frequency report about the differences participants found between the mobile EF coaching support and other types of support services

The code	Number of participants	%
More personal/one-to-one, including meeting individualized needs	7	37%
Time flexible	3	16%
Convenient/mobile EF is always there	2	11%
Easy to use and easy to access	2	11%
Talking in person better than on the phone	2	11%

More useful	1	5%
Setting up obtainable goals	1	5%
I haven't used others	2	11%

Chapter 5

Discussion

The mobile EFs coaching study aimed to explore the design of a mobile EF coaching solution to support students with EF challenges in post-secondary STEM gateway classes. The study also explored and confirmed how to provide EF coaching service to support learning processes for those students with diverse learning needs in post-secondary STEM education. Specifically, the researcher used mixed methods to identify students' perceptions of features of the mobile EF coaching in supporting their EFs, the personal outcomes of participation in the mobile EF coaching support, and the differences between the mobile EF coaching support and other types of support services for those students in post-secondary STEM education. A major identified advantage of mixed methods research was applied in this study, in which the researcher can both answer confirmatory and exploratory questions and therefore can confirm and develop knowledge in the same study (Teddlie & Tashakkori, 2003). The great potential of mobile technology to support individuals with EFs challenges in post-secondary STEM was explored and demonstrated through changes in participants' EFs in this study. The study was needed given the necessity of an increasing STEM workforce and promoting STEM diversity. This study contributed to the investigation of the design and the impact of providing an EF coaching service through a mobile platform to support the success and persistence of individuals with a range of disabilities in post-secondary STEM education.

The demand for a STEM workforce is directly related to the need to strengthen the economy and maintain a leading global role in scientific and technological innovation (National Science Board [NSB], 2010). The urgency of addressing this demand is highlighted by the amount of research efforts and funding invested in a series of interventions to expand and diversify the STEM workforce. The primary goal of this study was to develop transitional interventions to support active learning and to include historically under-represented groups in advanced education and STEM professions. This study specifically investigated the design and impact of mobile EF coaching support on the success and persistence of students in post-secondary STEM education, indicated by the literature that individuals with EF challenges struggled in STEM gateway classes.

Aiming to provide support for the development of skills, strategies, and beliefs to manage EF challenges, the researcher developed a design-based package on a mobile app to coach students on how to set and modify academic goals (e.g., SDLMI), time management skills, and assignment/task management skills. The results of the study showed that the coaching service supported students with self-managing and self-directing the learning process. Seven students participated in this mobile coaching study. A descriptive statistics method was used to describe the basic features of the data in this study. The descriptive statistics provided simple summaries and a comparative analysis of the pre/post test results for all participants to understand the changes in their learning strategies and EF skills through participating in this study. Two levels of coding methods were used to analyze the qualitative content of all coaching sessions. The students' perceptions indicated that the coaching support improved their ability to self-manage the learning process. Specifically, the results of participants' EFs in pre/post-test of the BDEFS-LF and LASSI scales showed the impact of mobile EF coaching support on students' learning strategies and skills. In addition, the qualitative content analysis of six weekly surveys and six coaching sessions also identified improved learning strategies and skills for all participants in this study.

Summary for All Participants with EF Challenges in Post-Secondary STEM

This study investigated the design and impact of a mobile EF coaching support for individuals with EF challenges in post-secondary STEM education to address the existing concern for high dropout and low graduation rates of those students in post-secondary education. Existing literature identified that individuals with a range of disabilities, including ADHD, LD, ASD, depression, or various forms of brain injury, may encounter EFs challenges (Parker & Boutelle, 2009; American Psychiatric Association, 2017). However, the existing literature regarding EF coaching and individuals with disabilities frequently focused on students with LD and/or ADHD. Moreover, past studies and intervention packages lacked the use of mobile technologies to support these coaching techniques. This study specifically aimed to investigate a mobile coaching technology solution across a variety of learners.

One major finding about this study was to identify specific EF challenges in different extents for of all seven participants through the results of pre-test LASSI and Barkley-LF scales and individual coaching sessions. To some degree, the identification of EF challenges helped to understand learner variability and why and how those students struggled with their performance and persistence in STEM gateway courses. In addition, based on the Barkley-LF and LASSI findings (Parker, Field, Sawilowsky, & Rolands, 2012), the analysis of the coaching sessions conducted with students who participated in the coaching model supported those findings. In this study, STEM gateway courses specifically refer to the initial post-secondary mathematics courses in STEM areas taken by a freshman or sophomore at a large research-focused university in the U.S. Students have experienced different challenges in the learning processes when taking STEM gateway classes. Those challenges may include working memory (i.e., remembering all formulas in a mathematics course), time management (i.e., over scheduling), procrastination (i.e., procrastinating on certain projects), identifying learning resources and self-advocacy (i.e., the competence of the professor teaching the classes), assignment/task management (i.e., struggling with keeping on top of calculus assignments), and stress management (i.e., having a mix up with medication, which causes a lot of mental and anxiety problems). The results of this study indicate that mobile EF coaching support appears to successfully solve challenges that college students with ADHD, LD, and other types of disabilities face during the learning process, specifically difficulties in the area of EF, including time management, assignment/task management, and goal setting.

The existing literature regarding EF coaching and individuals with disabilities frequently focuses on students with LD and/or ADHD, while the results of the mobile EF coaching service suggest that students with various learning needs, including students with and without disabilities, can benefit from the EF coaching service. The suggested essential cognitive and behavioral approaches to support individual EFs include seeking information, note taking, planning and organizing learning tasks, and using available learning resources (Rachal, Daigle, & Rachal, 2007; Parker & Boutelle, 2009). Through this coaching study, participants were provided with learning resources and tools (i.e., learning strategies and skills) to problem solve their challenges in post-secondary STEM classes and to meet their personalized learning needs during the learning process. Every participant responded in the survey that coaching benefited their learning. Overall, all seven participants reported that coaching helped them with learning strategies and skills to help them improve their academic performance in STEM gateway classes. Those strategies and skills included setting academic goals, managing time, managing assignments, acquiring information, organizing and planning learning, and identifying available learning resources and self-advocating. For all seven participants with EFs challenges, their pre/post-test EF summary scores in BDEFS-LF scale were reduced. The reduced total raw EF summary scores of all participants were from four major subscales in BDEFS-LF, including scores on self-management to time, self-restraint, self-organization/problem solving, self-motivation, and self-regulation of emotions. Their symptoms of EF deficits also decreased.

Furthermore, this mobile EF coaching study explored and demonstrated how a coach and participants can work together to monitor and evaluate the learning progress. Robinson & Gahagan (2010) stated that the fundamental concepts of coaching interventions included self-assessment, reflection, and goal setting. In this study, the researcher adopted those major concepts in the coaching intervention. The coach provided immediate feedback to help participants stick to their plan and achieve self-identified academic goals. Some changes were made to adjust goals individually when necessary. During the monitoring process, the coach modeled how to reflect and evaluate the learning progress. Then the participant took the lead to self-assess and reflect on their own progress.

Limitations

Several limitations exist in this study. First, only seven individuals with EFs challenges in their STEM gateway classes participated in this mobile EF coaching support study. Only three (43%) students with disabilities and/or some health conditions participated in the study. In addition, detailed information about students' mediation usage was not collected in this study. Even though students identified available support services on campus, detailed information about support to accommodate students' disabilities was not collected. That information could help identify the circumstances under which EF coaching is most helpful for individuals with EFs challenges in post-secondary STEM education.

Future research should include more students, wherein participants could be placed in an experimental treatment design (e.g., with a control group and an experimental group). The comparison of learning outcomes for participants in a control group and an experimental group can possibly provide research evidence of understanding the impact and effectiveness of mobile EF coaching service in supporting the learning process. Even though the pre/post-testing sample results showed substantial EFs changes in the reported subscales, the study had limited statistics power to predict EFs changes due to small sample size. Therefore, the pre/post-testing sample results indicated that this mobile EF coaching solution is promising in providing EF support to individuals with EF deficit and requires further research to provide statistics power through experimental studies.

Additionally, all participants were enrolled in one university, potentially representing a homogeneous group. These factors limit the generalizability of the results with regard to students with various social and cultural backgrounds. Second, the coaching sessions lasted eight weeks altogether, including two sessions of face-to-face training and six sessions of personalized mobile coaching meetings. Based on the existing literature, the coaching sessions in some studies lasted from seven to eight weeks, and others lasted from one to five academic years. The length of each coaching session and the length of the study itself can be another variable that impacted the EF coaching support on student learning and academic performance. Third, due to time constraints, the researcher did not include maintenance probes as part of the study design. For a future study, the design of using the same instruments for the pretest, posttest, and maintenance probes could measure gains and durability in strategies and skills following receiving mobile EFs coaching support sessions.

Implications

The mobile EFs coaching support study provided implications for both future practice and research on designing and developing EFs coaching supports in post-secondary STEM education. Specifically, the use of UDL frameworks, the design of mobile coaching activities, and the integration of mobile technology could inform practices and research when providing EF coaching service to support the success and persistence of individuals with and without disabilities in post-secondary STEM education.

Implications for Future Practice

As indicated by the existing literature, mentoring or academic coaching may be a key strategy for supporting educational persistence, including within STEM, for SWDs (Gregg et al., 2016). The results of improved learning strategies and skills in pre/post LASSI and Barkley-LF, as well as the qualitative content analysis of each coaching session for all seven participants, were in line with existing literature regarding the impact of EF coaching practices on individual EFs and learning strategies. Specifically, the recommendations of using mobile EF coaching support in practice can focus on meeting personalized learning needs, providing just-in-time feedback, and building research experience into the curriculum.

Personalized learning needs. Many participants identified that this mobile EF coaching support is more personal (i.e., one-to-one) and meets individualized needs. Indeed, the coach identified learner variability and diverse learning needs during the EF coaching practice. The coach recognized and understood that every individual is different and that even similar backgrounds and the same disability can impact people differently. The coach tailored each coaching session to the specific needs of each participant based on the challenges they experienced in their STEM gateway classes. In a modern learning environment, learner variability exists within differences in gender, culture, education background, prior knowledge, motivation, interests, etc. (CAST, 2008). It was especially challenging to identify the learning needs of individuals with a range of disabilities and provide necessary support to meet those needs. The purpose of personalized learning is to develop individualized learning programs for each learner with the intention to engage everyone in the learning process to improve learning potential and success (Song, Wong, & Looi, 2012). Personalized learning presents a means to tailor to an individual's interests, existing knowledge and skills, and other diverse needs (Song et al., 2012). It is important to provide support across a diverse array of learning needs through adopting and integrating supports that use multiple means of representing content, allow students to use multiple ways to take action and express understanding, and utilize multiple means of engagement (CAST, 2011). To support a student's learning process, coaches need to understand learner variability, support the context in which they operate, give options to empower them to make choices in learning, and monitor their learning progress with immediate feedback. For individuals with a range of disabilities, this coaching solution potentially provides opportunities and support student success and persistence in STEM classes.

Just-in-time feedback. Mobile technology and its applications (i.e., WhatsApp) enables teaching and learning beyond the classroom's borders (Bouhnik & Deshen, 2014). During the mobile coaching sessions, the coach provided immediate feedback to each participant in the process of identifying challenges, setting obtainable and clear goals, providing learning strategies and skills, and evaluating learning progress. Providing feedback is aligned to what is known as research-based practice. For instance, in his meta-analysis of effective instructional practices, Hattie (2009) identified that feedback (effect size of .73) ranks in the top 10 of all possible teacher behaviors that facilitates student success. Other researchers also argued that the high availability of instructors to learners' questions may support the learning process (Bouhnik & Deshen, 2014). The flexibility of mobile EF coaching, regardless of time and space, makes it possible for coaches to monitor each individual's learning progress and to provide immediate feedback as needed. Mobile technology plays an important role in supporting instructional practices and learning inside and outside of the classrooms.

Building research experience into the curriculum. The research on the participatory design of the mobile EF coaching study to understand and support students' needs requires further investigation. In this study, participants expressed their interest in getting involved in research projects on coaching sessions. One participant pointed out that building an EF coaching project into the curriculum may empower each learner to manage and self-direct their learning process. Indeed, substantial research evidence suggests that engaging in hands-on research projects, whether within an academic setting or in an institutional position, effectively increases the number of individuals who advance their education and careers in STEM fields (Bauer & Bennett, 2003; Tsui, 2007). Specifically, studies identified that undergraduates who are involved in research projects can benefit from clarifying educational and career plans, improving their sense of self-efficacy, and forming mentorships through closely working with faculty and researchers (Tsui, 2007). In addition, the results of many empirical studies showed that coaching is a cost-effective method of improving student academic performance (Field et al., 2013; Bettinger & Barker, 2013). In this mobile EF coaching study, three participants indicated that they would like to have the coach write them a reference letter for their jobs or graduate school applications. The researcher has confirmed with two participants to provide a reference letter for their job applications. Potentially, the consideration of involving students in EF coaching research projects when developing a curriculum can support the success and persistence of SWDs in post-secondary STEM education.

Implications for Future Research

The study of mobile technology has received increasing research attention in formal and informal educational settings (Xie et al., 2017). Specifically, more research attention was given to how to effectively deliver existing learning materials into an appropriate version to meet the needs of learners and the affordances of mobile devices (Su, Tseng, Lin, & Chen, 2011). Many affordances of mobile technology and applications in existing educational studies showed contributions to the learning process such as encouraging collaborative learning, promoting active participation in class activities, learning without time and place constraints, and fostering communication outside of the classroom through the integration of social networks and instant messenger tools (i.e., Facebook, WhatsApp, WeChat) into educational research (Bouhnik & Deshen, 2014). For instance, researchers found that mobile devices can bridge different learning content and contexts as well as virtual and face-to-face learning interactions in post-secondary education to nurture individual and collaborative learning (Looi et al., 2012). However, the research of mobile technology in the field of education is still emerging (Bouhnik & Deshen, 2014; Xie et al., 2017). Recommendations for future research primarily focus on the use of design-based research (DBR) (Brown, 1992; Collins, 1992) and UDL frameworks in the design and development of transitional interventions through instructional technology to support the learning processes of SWDs in post-secondary STEM education.

Implications of using DBR and UDL frameworks in research. In future mobile application design processes, DBR may be useful for supporting the iterative process of designing, testing, reflecting upon, and reshaping the e-mentoring application (Wong, Boticki, Sun, & Looi, 2011). DBR, as a systematic but flexible methodology, aims to study learning and develop educational practices through an iterative and reflective design process based on collaboration among researchers and practitioners in real-world contexts, which leads to contextually-sensitive educational design principles and theories (Wang & Hannafin, 2005; Reeves, 2006).

DBR was taken out from the original design, as it was debatable among the researcher's dissertation committee members that there was only one cycle of testing and no redefining mobile EF coaching solution in this study. The same design package was used during each coaching session. The outcome of using the design package met the goal at the first cycle of testing and redefining mobile EF coaching solution. The study ended at the first cycle . The researcher and participants completed the coaching activities via the video/phone function of the WhatsApp application, with additional check-ins via email/voice mail/text. The meeting schedule was set up according to each student/participant time/desire to meet each week. Each participant's self-report on their GAS outcome was used to monitor the learning progress and to evaluate whether the weekly goal was achieved. Each coaching session started with academic goal setting and revisiting GAS (Shogren et al., 2012; Ruble et al., 2012). These goals were used to guide all coaching sessions in the study. The goals were broken down into daily and weekly goals and were measured through GAS. Based on each individual's progress on weekly academic goals, the researcher decided what activity to coach in the following week. All participants reported that they met their personalized academic goals in almost every coaching session, except one participant, who achieved the goal at a less than expected level in the last coaching session.

The potential benefits of using DBR in educational research may include 1) managing the research process collaboratively with participants, 2) designing and implementing interventions systematically to refine and improve designs, and 3) advancing both pragmatic and theoretical objectives to inform practice (Wang & Hannafin, 2005). In general, DBR involves flexibility in the iterative design process, multiple variables in complex real-world problems, and capturing social interaction (Barab & Squire, 2004). Similar to what Anderson and Shattuck (2012) noted, the designing of innovations was like "research through mistakes" in a specific learning environment. All of those characteristics of DBR may help researchers understand learner variability and identify diverse learning needs in complex real-world contexts. In addition, DBR can handle some of the weaknesses of other research methods in examining the role of tools and techniques in supporting the learning process (Amiel & Reeves, 2008). However, DBR has not focused on the transformative role of the use of technology in teaching and learning in education (Amiel & Reeves, 2008).

Indeed, DBR methodology can be widely used on studies in the field of learning sciences and technology enhanced learning (i.e., Barab, 2006; Edelson, 2002; The Design-Based Research Collective, 2003). DBR studies involve introducing an intervention or solution in a naturalistic setting (Schmitz, Klemke, Walhout, & Specht, 2014). In DBR studies, researchers observe and collect data on how an intervention or solution functions to support learning in order to better understand the procedures and instructional tools that worked in real-world classrooms (Schmitz et al., 2014). One primary goal of DRB is to build a strong connection between educational research and solving real-world problems (Amiel & Reeves, 2008). In the future study, DBR can identify the learning needs of SWDs in post-secondary STEM gateway courses and examine the design of a mobile EF coaching solution to support the EFs and learning strategies of those students.

Often used to support the rapid testing of an innovation (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003), DBR methodology has the following several advantages in research. First, a study with DBR methodologies happens in real learning settings. Second, a study with DBR methodologies can inform practice (Brown, 1992). Third, DBR promotes direct collaboration between the researcher, practitioner, and students. Through the collaboration process, educator concerns can be addressed, and expertise can be utilized (Wang & Hannafin, 2005). Educators can contribute to inquiry with a focus on using both their knowledge and awareness of their classroom contexts (Linn et al., 2003). They are skilled in observing student behaviors change during the inquiry process, and they may provide guidance and feedback with their classroom expertise. Forth, DBR may contribute to advancing existing theory or developing new theories in a context full of uncertainty, which can promote an expanded understanding of learning (Kennedy & Clark, 2013).

The integration of DBR with a UDL framework into research seems promising. The primary goal of UDL is to help all learners become expert learners who can self-assess their learning needs; monitor their learning progress; and manage their interests, efforts, and persistence to accomplish learning tasks (CAST, 2012). To empower learners to self-assess and direct their learning requires learners to develop their own learning strategies and skills. In addition, researchers argued that UDL creates a student-centered environment that uses technology tools to meet desired learning outcomes with a combination of evidence-based practices (Basham, Meyer, & Perry, 2010). The UDL framework may provide a new way to consider the design and supports across post-secondary environments through bringing flexibility and creativity in delivering content, managing instruction, and learning in inclusive higher education settings (Roberts, Park, Brown, & Cook, 2011). In the DBR process, Reeves (2006) illustrated the individual steps of the underlying design process, including an iterative procedure to scope problems by researchers and instructors in collaboration, develop a solution to the problematic situation, and incorporate the research of the solution into real educational practices.

In the design process, both DBR and UDL frameworks emphasize the identification of the diverse learning needs of individuals and designing solution features to satisfy those needs and meet desired outcomes (Anderson and Shattuck, 2012). In addition, the space for reflection and refinement in the design process and for re-evaluation is always necessary when applying DBR and UDL frameworks.

Implications on developing transitional interventions and support in search. Although EF coaching has some evidence in improving EF skills, there is a lack of empirical studies that investigate the efficacy of EF coaching in post-secondary education in general (Franklin & Franklin, 2012). Overall, continued research efforts are needed to provide supports associated with the learning process to develop individualized college and career readiness competencies in inclusive education (Hunt, McDonnell, & Crockett, 2012; Morningstar et al., 2017). The existing literature on EF coaching focuses on students with ADHD and/or LD (Bellman et al., 2015). The results of existing studies suggest that EF coaching appears to be a feasible option to assist students with ADHD and/or LD in transitioning to post-secondary educational settings (Parker & Boutelle, 2009; Field et al., 2013). In addition, the findings of the literature indicate that transitioning into post-secondary education that provides less external control and needs an increase of self-regulation is challenging for students with EF challenges (Parker & Boutelle, 2009). In the existing literature, students with a range of disabilities can benefit from EF coaching in post-secondary STEM education (Bellman et al., 2015). This study contributes to the literature by examining the design of a mobile EF coaching solution for individuals with and without disabilities in post-secondary STEM education. There is need for empirical studies that examine the efficacy of developing EF learning strategies and skills that can be deployed via mobile technology tools for STEM gateway courses.

Summary

Despite the positive impact of the mobile EF coaching support in this study, for it to be adopted by others, there is need for additional research in using this type of tool and intervention. In addition, the research base on EF coaching is still growing, although the results of existing studies point toward the promise of tools and interventions to support the success and persistence of individuals with EFs challenges in post-secondary STEM education.

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Appendix A. BDEFS-LF Test Review and LASSI Overview

In this study, the researcher adopted the Barkley Deficits in Executive Functioning Scale (BDEFS), authored by Russell A. Barkley and published by Guilford in 2011, as an assessment tool that to evaluate the EFs for adults ages 18 to 81. The scale includes 89 items in the final version of the self-report long form (BDEFS-LF) (Allee-Smith, Winters, Drake, & Joslin, 2013). This measure aims to screen those who may be experiencing EF deficits in the areas of self-organization, self-restraint, self- motivation, self-regulation of emotion, and self-management to time (Allee-Smith et al., 2013). Based on Allee-Smith and her colleagues (2013), the BDEFS is the only existing instrument that can evaluate the type and extent of EF deficits present in daily activities over an extended period of time. The test review also reports the normative sample, reliability and validity for the BDEFS self- report forms. The BDEFS is suggested as a time and cost-efficient means of identifying adults with potential EF deficits to be administered in various settings, including a clinical, research, or industrial-organizational setting (Allee-Smith et al., 2013). For more detailed description and review of the BDEFS, please refer to “Test Review: Barkley Deficits in Executive Functioning Scale (BDEFS)” by Allee-Smith and her colleagues (2013).

In this study, the researcher used the Learning and Study Strategies Inventory (LASSI) scale as learning strategies/skills measurement. LASSI consists of 10-scale, 60-item assessment of students’ awareness about and use of learning and study strategies related to skill, will and self-regulation components of strategic learning (Weinstein, Palmer, & Acee, 2016). Those learning strategies/skills are important to the success and persistence of students in postsecondary educational and training settings (Weinstein et al., 2016). Research has showed that these factors (i.e. thoughts, behaviors, attitudes, motivations and beliefs) contribute significantly to success in college and that they can be learned or improved (Weinstein et al., 2016). The LASSI can provide diagnostic and prescriptive information (Weinstein et al., 2016). The LASSI specifies standardized scores (percentile score equivalents) and national norms for ten different scales (Weinstein et al., 2016). For more detailed information of LASSI, please refer to “LASSI 3rd Ed User's Manual - H & H Publishing”, authored by Weinstein, C. E., Palmer, D. R., & Acee, T. W. and published by H&H in 2016.

Appendix B. The questionnaire

Note: this questionnaire was on Qualtrics.

A questionnaire about students' usage of mobile devices and students' self-report to answer the following questions to identify challenges, strengths, resources, and perceived needs as well as his/her expectations for coaching (5 minutes).

1. What is the brand of your phone:

2. Do you have data plan on your phone:

3. To identify the operating system of the smartphone (i.e., Apple iOS, Android, and Windows) why did you choose this phone? What features and functions of the phone do you like and dislike? How does the user experience of this product compare to the competition?

4. How do you think about using mobile devises in your academic learning? If you use mobile devices in your academic learning, can you use 2-3 sentences briefly describe your preferences with regards to content, method, and time?

5.What are the challenges in your current STEM class?

6. What are your strengths in doing academic work?

7. What are the resources that you can use to help your learning in STEM class?

8. Do you plan your academic work daily and weekly?

9. Do you stay on track to follow up your plan in completing academic work?

10. What do you need at this moment to support your STEM class?

11. What are your expectations for the coaching to help your learning in STEM class?

Appendix C. Weekly Survey

Note: this is going into Qualtrics.
We would love to get your feedback on the mobile application in this study. (Adapted from Bellman, Burgstahler, and Hinke, 2015).

Item 1. Based on features/affordances the mobile EF coaching solution, in what ways, if any, has participating in the mobile EF coaching activities helped you achieve your educational or personal goals?
Please give scores from 1 to 5 to the following items based on your learning experience. The mobile EF coaching solution refers to provide EF coaching support through WhatsApp. From 1 to 5, the range of number represents

1	2	3	4	5
strongly disagree,	disagree,	neutral,	agree,	strongly agree:

The mobile EF coaching solution helps you in the following ways:
1.1 improve goal setting, prioritization of goals, or goal advancement
1.2 provide you effective strategies to set up goals
1.3 clarify goals or provide support for goals
1.4 improve time management skills
1.5 improve assignments management skills
1.6 improve ability to focus/stay on tasks
1.7 have access to the EF coaching application at different locations
1.8 have access to the EF coaching application any time I want
1.9 Please identify the locations where you frequently use the app ___________________
1.10 Please identify when you frequently use the app _______________________________
1.11If you have other comments, please provide your comment here _______________.

Item 2. Do you feel that participating in the EF coaching via mobile application sessions has made a difference in where you are today?
Yes   No   I do not know

(If you choose Yes in item 2, the survey will take you to Item 3 and Item 4. If you choose No or I do not know in item 2, the survey will take you to Skip Item 3 and Item 4 and take you to Item 5.)

Item 3. Please describe the differences you have experienced as the result of participating in the mobile EF coaching support. What, specifically, has changed? From 1 to 5, the range of number represents

1	2	3	4	5
strongly disagree,	disagree,	neutral,	agree,	strongly agree:

The EF coaching application helps you
3.1 improve self-awareness or confidence
3.2 improve organization
3.3 improve prioritizing skills

3.4 improve goal-setting skills
3.5 feel being supported
3.6 improve learning strategies or knowledge retention
3.7 improve the sense of belonging
3.8 If you have other comments, please provide your comment here _______________.

Item 4. List three or more strategies or skills you have learned as a result of participating in the EF coaching via mobile application sessions. You can make multiple choices among the following:
4.1 Goal setting
4.2 Time management and organization skills
4.3 Assignments management and organization skills
4.4 Study skills
4.5 Breaking projects into smaller steps or making outlines
4.6 Self-awareness
4.7 Utilizing existing resources
4.8 Stress management
4.9 Being focused/staying on tasks
4.10 Knowing how to ask help from peers/instructors/staff

(If you choose No in item 2, the survey will take you to Skip Item 3 and Item 4 and take you to Item 5.)

Item 5. Do you think participating in the mobile EF support impacts your academic performance in STEM courses? From 1 to 5, the range of number represents

1	2	3	4	5
strongly disagree,	disagree,	neutral,	agree,	strongly agree:

Item 5. I believe participating in the mobile EF support impacts my academic performance in STEM courses

Please leave comment here on why you make this choice: ________________

Item 6. Please provide suggestions or recommendations for mobile EF coaching support to better provide services and activities to assist you and other students with disabilities.
Please leave your comment here: _____________________________

Item 7. Have you attended any other types of support services for SWDs in postsecondary STEM education besides this mobile EF coaching support? You can choose more than one:
7.1 tutorial services
7.2 academic skills centers
7.3 peer mentoring to facilitate team learning
7.4 academic coach
7.5 career advising
7.6 writing centers
7.7 Do you find any differences between this mobile EF coaching support and other types of support services? Please provide your comment here. Please provide your comment: ________

Appendix D. Goal Attainment Scaling

Note: this is going into Qualtrics.
Goal Attainment Scaling—Goal Attainment Scaling (GAS) will be used to collect data on student progress on academic goals.

GAS (how to solve problems through creating plans and goals)

Level of Expected OUTCOME 2 months after the coaching	Rating	Statement of Expected outcomes: -Academic Goal 1	Statement of Expected outcomes: -Academic Goal 2
Much more than expected	+2		
More than expected	+1		
Expected outcome	0		
Less than expected	-1		
Much less than expected	-2		

Appendix E. Flyer 2018

Appendix F. Consent Letter to Students

Dear Participants,

The School of Education at the University of Kansas supports the practice of protection for human subjects participating in research. The following information is provided for you to decide whether you wish to participate in the present study. You should be aware that even if you agree to participate, you are free to withdraw at any time without penalty.

The researcher is conducting this mobile executive function (EF) coaching support study to investigate the design of academic coaching on a mobile application for students with disabilities (SWDs) in Science, Technology, Engineering, and Mathematics (STEM) gateway courses (i.e., mathematics, chemistry). The second purpose of this study is to develop EF learning strategies that can be deployed via mobile technology tools for taking STEM classes.

For the purpose of this research, the term academic coaching was defined as a "one-to-one interaction with a student focusing on strengths, goals, study skills, engagement, academic planning and performance" (Robinson & Gahagan, 2010). EF coaching refers to "a specialty within the burgeoning field of personal coaching, and provides support for the development of skills, strategies, and beliefs needed to manage executive function challenges" (Parker & Boutelle, 2009, p 205).

This study will entail your completion of a study with Part 1 preparation stage in Fall 2017 or Spring 2018 and Part 2 the mobile EF coaching activity stage in Spring 2018. You are expected to take approximately 2 hours to complete Part 1. In Part 2, you and the researcher will work individually and it will take approximately 30 minutes per week to complete the coaching activities. Participants do not need to interact with each other throughout this study. Please see Table A for detailed information about the study plan.

Table A. Brief introduction of the study plan and participant time commitment

<table>
<tr><th rowspan="2">Stages / tasks</th><th colspan="2">Part 1
Preparation 2 hours</th><th>Part 2
Coaching activities (Spring 2018) 3.5 hours</th></tr>
<tr><th colspan="2">W1 recruitment; W 2, 3 (50 minutes/ per week)</th><th>W 1, 2, 3, 4, 5, 6 (30 minutes/per week)</th></tr>
<tr><td>Goals</td><td>Participants Recruitment</td><td>Brief introduction, screening, the training, & goal setting</td><td>Intervention begins at W1; it ends at W6; procedures will be the same every week</td></tr>
<tr><td>Tasks</td><td>Baseline requirement; Incentives</td><td>EF scale; a questionnaire (mobile device usage)</td><td>Weekly survey; At the end of W6, EF scale & Goal Attainment Scaling</td></tr>
<tr><td>Detailed procedures</td><td colspan="2">In Week 1, email recruitment and STEM gateway courses talk; In Week2, face to face meeting to complete screening and a five minute questionnaire about their usage of mobile devices; In Week3, training through face to face meeting</td><td>First, to set up individualized weekly and daily learning goals. Second, time management or assignments management activity will be coached based on participants' request. Third, participants take a survey to give weekly feedback.</td></tr>
</table>

	to introduce the basic features of the app, the coaching process, coaching plan, & how to set up goals.	

Involvement in the study should pose no risks. The researcher just wants to understand the challenges in your learning processes in your STEM courses and to provide necessary support to problem solve those challenges and improve your learning outcomes. With your permission, the study will be audio/video recorded and transcribed by the researcher for later analysis. The audio/video taping is part of the research procedure, and the participants will have the option of not being taped or having taping stopped at any time; the participant will have the option to choose the type of the recording one would like to participate in the study procedures. Only my dissertation advisor and I will have access to the recordings and the recordings will be erased / destroyed after data analysis has been completed in the dissertation and other subsequent manuscripts.

To be considered for inclusion in this study, you must own a mobile device (i.e., smart phone (iPhone, Samsung or an iPad) and be capable of using it. Although participation may not benefit you directly, the information obtained from this study will help us gain a better understanding of and will improve research on mobile technology, and supporting students on setting up goals, learning strategies, and stress management in their learning processes, which potentially impact your lifelong learning.

Your participation is solicited, although strictly voluntary. Upon completion of your participation, you will receive a $10 pre-loaded debit card if you are solicited and complete Part 1, which can be used in any business that accepts MasterCard. Upon completion of your participation, you will receive a $30 pre-loaded debit card if you are solicited and complete both Part 1 and Part 2.

Investigators may ask for your social security number in order to comply with federal and state tax and accounting regulations.

Your name will not be associated in any publication or presentation with the information collected about you or with the research findings from this study. Instead, the researchers will use an identification number rather than your name. Your identifiable information will not be shared unless (a) it is required by law or university policy, or (b) you give written permission. Researchers will ensure that all the information collected as part of this study will be kept confidential. Electronic data will be kept on a secure server* of the KU School of Education. All physical documents will remain locked in a filing cabinet. Only the primary investigator will have access to these materials.

**It is possible, however, with internet communications, that through intent or accident someone other than the intended recipient may see your response.*

Thank you in advance for your willingness to participate in this study. I plan to share our findings with the school as well as at a national conference in near future because I believe this information gathered can benefit students at the University of Kansas and other universities across the country. If you have any questions or concerns, please feel free to contact Jingrong Xie at 908-548 4924 or jrxie@ku.edu, or my academic advisor Dr. James Basham at (513)593-1677 or jbasham@ku.edu.
Sincerely,
Jingrong Xie, and James Basham

I have read this Consent and Authorization form. I have had the opportunity to ask, and I have received answers to, any questions I had regarding this study. I understand that if I have any additional questions about my rights as a research participant, I may call (785) 864-7429 or (785)864-7385, write to the Human Research Protection Program (HRPP), University of Kansas, 2385 Irving Hill Road, Lawrence, Kansas 66045-7568, or email irb@ku.edu.
I agree to take part in this study as a research participant. By my signature I affirm that I am at 18 years old, I have received a copy of this Consent and Authorization form, and I give permission for this study to be audio recorded.

Print Participant's Name

_______________________________________ Date __________________________

Signature of Participant

_______________________________________ Date __________________________

Social Security Number

The type of the recording is optional. Please sign your initial to consent specifically for the audio and/or video recording in this study.

Audio recording ( ) Video recording ( )

Appendix F. Recruitment Email

The following information is provided for you as you decide whether you wish to participate in the present study. This study investigates the design of academic coaching on a mobile application, including Part 1 and Part 2.

Part 1: Preparation Stage will take a student one hour. In this session, you are expected to complete consent form if you are willing to participate in the study. A brief introduction of the study will be informed. Then, students are expected to take 3 surveys (to understand your learning strategies skills, your interests, learning needs) around 30-40 minutes. The results are confidential and will help the researcher to select participants for the coaching activities session.

Part 2: coaching activities will take place for 7 weeks (30 minutes per week) in Spring 2018. No coaching session in Spring break. If you participate in Part 2 of the study, you and the researcher will work individually through a mobile application to complete the coaching activities. Involvement in the study should pose no risks as there are no right or wrong answers and you are free to withdraw at any time without penalty.

To be considered for inclusion in this study, you must own a mobile device (i.e., smart phone (iPhone, Samsung or an iPad) and be capable of using it. Your participation is solicited, although strictly voluntary. Upon completion of your participation, you will receive a $10 pre-loaded debit card if you are solicited and complete Part 1, which can be used in any business that accepts MasterCard. Upon completion of your participation, you will receive a $30 pre-loaded debit card if you are solicited and complete both Part 1 and Part 2.

If you have any additional questions about your rights as a research participant, you may call (785) 864-7429 or (785)864-7385, write to the Human Research Protection Program (HRPP), University of Kansas, 2385 Irving Hill Road, Lawrence, Kansas 66045-7568, or email irb@ku.edu.

Appendix G. SLDMI model

Please refer to the following questions to set up a specific academic goal in SDLMI (Shogren et al, 2017).

1. What do you want to learn or improve on this semester? You can have more than one academic goal.
2. What are the explicit reasons, purpose or benefits of accomplishing the goal?
3. What do you know about it now in class?
4. What must change for you to learn what you do not know in that class?
5. What can you do to make it happen?
6. What can you do to learn what you do not know?
7. What could keep you from taking action?
8. What can you do to remove these barriers?
9. When will you take action?

Questions to reflect and evaluate when set up a specific academic goal in SDLMI (Shogren et al, 2017):

1. What actions have you taken?
2. What barriers have been removed?
3. What has changed about what you do not know?
4. Do you know what you want to know?
5. Did you finish your goal?

Appendix H. Procedures of the Study

1. Part 1 Preparation

Week 1 **Recruitment**

1) I sent email invitation and recruitment flyer three times to prospective participants through student disability service office (AAAC), Trio, ADA Resource Center for Equity & Accessibility, Kansas Algebra Program (KAP), and School of Engineering. The recruitment flyer was also posted in multiple locations on campus, including Dole Human Development Center, Anchutz library, Watson Library, School of Engineering building, and Learning Center at School of Education. If interested, students replied to email or texted message to the researcher, as a response to enroll in the study.
2) The researcher also asked STEM gateway course (i.e., mathematics) instructors to send the email invitation to their students. The researcher also went to STEM classes to give a 5-minute brief introduction of the study.

Week 2 **Screening**

In Week 2, the first meeting in a classroom in School of Education, face-to-face, was around 50 minutes. During the first meeting, they completed the following actions:

1) To complete consent form. A brief introduction of the study included the purpose, the benefits, and possible concerns to the students. Students who were willing to participate in the study need to sign a consent form of information.
2) A questionnaire about their usage of mobile devices and students' self-report to answer the following questions to identify challenges, strengths, resources, and perceived needs as well as his/her expectations for coaching. The questionnaire took each participant three to five minutes (5 – 10 minutes). For the content of the questionnaire, please see Appendix B.
3) The researcher administered pre-test of EF scale and LASSI scale. The two scales took 30-40 minutes in total.
4) After face-to-face session, the pre-test data was analyzed. Participants were informed individually about their EF scale scores. The researcher coded and analyzed the self-report data of all participants with and without disabilities. The data were analyzed and used to understand personalized learning needs of those participants.

Week 3 **Training**

In Week3, the second meeting in a classroom in School of Education, face-to-face, took around 50 minutes. During this meeting, they completed the following actions:

1) The researcher discussed Coaching Plan with participants. The researcher and the participant met weekly for 30 minutes via WhatsApp every week (coach and participant chose their time based on participant's desire and needs) (3 minutes).

1) Explained how to use WhatsApp. The researcher introduced the basic features and the functions that were going to be used in this study. The researcher addressed questions of the EF coach regarding the coaching process, what coaching "looked" like, measures of progress, confidentiality, time, WhatsApp features etc. The researcher asked questions to make sure coaching readiness, understanding of the coaching process and WhatsApp features to be used in this study,

preparedness to engage in the coaching process, and to determine areas of concern/interest for coaching (5 minutes).

2) To coach and model how to set up personalized academic goals and develop goal attainment scaling (GAS) (Carr, 1979; Shogren, Palmer, Wehmeyer, Williams-Diehm, & Little, 2012) (30 minutes). Structured protocols:
   i. Discuss the importance of goal setting. Provid specific examples from Self-Determination Learning Model of Instruction (SDLMI) goal setting procedures (Shogren, Wehmeyer, Burke, & Palmer, 2017).
   ii. Walked through how I set up my goals with the SDLMI goal setting procedures.
   iii. Please think about and share your answers/perspectives to the questions on learning how to set up a specific academic goal (Shogren et al, 2017). Please see Appendix G for goal-setting open-ended questions in SDLMI model.
   iv. Please tell me one or two academic goals that you want to achieve this semester. Then we develop goal attainment scaling (GAS) (Shogren et al, 2012) regarding those academic goals (10 minutes). When create the GAS, the participant and the researcher develop descriptors or benchmarks for each of the criterion levels (Ruble, McGrew, & Toland, 2012).

4) To introduce the layout of the study plan for Spring 2018 and to set up the schedule for the first week to meet (10 minutes). Structured protocols:
   i. Here is the study plan for Spring 2018. Please pick up the days that work for you in the plan. Every week we met once for 30 minutes through WhatsApp to coach goal-setting skills, time management, and assignments management skills. All together we met 6 times to complete this study.
   ii. Regarding questions and concerns, the researcher and participants will communicate with WhatsApp and additional check-ins via email/voice mail/text.

2. Part 2: Coaching activities intervention

In this session, in Week 1, 2, 3, 4, 5, 6, the same design package was used in each coaching session. The researcher and participants completed the coaching activities via video/phone function of the WhatsApp application with additional check-ins via email/voice mail/text. The meeting schedule was based on each student/participant time/desire to meet each week. The researcher implemented iterative cycles of testing & refinement of solutions in practice in this phase in order to provide coaching to meet individualized learning needs.

In each coaching session every week, the following procedures was followed:

1) Each coaching session started with goal setting and revisit GAS (Shogren et al, 2012; Ruble et al, 2012). The researcher and the participant set up and revisit one or two academic goals for semester Spring 2018. These goals guided all future coaching sessions. The goals were broken down to daily and weekly goals in the first 10 minutes of the coaching session. The participant led the process in the first 10 minutes in the session. Structured protocols:
   i. Please tell me one or two academic goals that you want to achieve this semester and revisit the developed GAS (Shogren et al, 2012; Ruble et al, 2012).

   ii. Based on your academic goals for this semester, please break down the goals into weekly base and tell me what you want to achieve this week.
   iii. Please tell me what you want to focus on in the coaching today between assignment management and time management. Please briefly explain why you would like to focus on it.
   iv. Please let me know if there are any questions for the coach.

2) Based on participants' request, the researcher coached each participant on how to manage assignments or how to manage time in each coaching session (20 minutes). Structured protocols:
   i. Since you want to learn how to manage assignments with a calendar, we will focus on assignment management today. I am going to use Chat, video, audio, or text via WhatsApp based on your learning need.
   ii. Please choose google calendar or the calendar app on your mobile devices to complete this activity. Then, I will explain and show you how I organize my assignments with google calendar (or the calendar on my iPhone).
   iii. Now please build your own calendar and organize all the assignments. If you have any questions, I would like to provide help and feedback to how to build your calendar.
   iv. Now Please take this weekly survey to provide your feedback on this mobile EF coaching solution (5 minutes).
3) The researcher documented research log. The researcher wrote down the coaching protocols, expectations, questions and thoughts before the session. The researcher then put down the coaching protocols and activities that happened in that session. The researcher documented the thoughts and questions for next session.
4) Based on the survey result, the researcher made reflection of the previous mobile EF coaching plan and coaching activities, and discussed the solution in detail, coming up an improved coach activity based on personalized needs for next week.
5) The researcher administered post-test of EF scale, LASSI scale and Goal Attainment Scaling. The EF scale and LASSI scale took 30-40 minutes in total. Goal Attainment Scale took 3-5 minutes.